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THE DEGENERATIVE DISEASES

LEWELLYS F. BARKER
AND
THOMAS P. SPRUNT

THE DEGENERATIVE DISEASES

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THE DEGENERATIVE DISEASES

THEIR CAUSES AND PREVENTION

BY

LEWELLYS F. BARKER, M.D.

Professor Emeritus of Medicine,
Johns Hopkins University.

AND

THOMAS P. SPRUNT, M.D.

Associate in Clinical Medicine,
Johns Hopkins University.

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First Edition

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CONTENTS

CHAPTER		PAGE
	PREFACE	vii
	PART I. GENERAL CONSIDERATIONS	
I.	INTRODUCTORY	3
II.	GENERAL DISCUSSION OF THE CAUSES OF DEGENERATIVE DISEASES	8
III.	THE RELATION OF HEREDITY TO HEALTH AND DISEASE	17
IV.	THE RELATION OF ENVIRONMENT TO HEALTH AND DISEASE	28
	PART II. THE PRINCIPLES OF PREVENTION AND OF POSTPONEMENT OF THE DEGENERATIVE DISEASES	
V.	EUGENICS	45
VI.	EUTHENICS	53
VII.	AIR AS A FACTOR IN EUTHENICS	62
VIII.	FOOD AS A FACTOR IN EUTHENICS	68
IX.	CARE OF THE EXCRETORY CHANNELS	78
X.	BACTERIAL POISONS	85
XI.	EXTRANEOUS POISONS OTHER THAN BACTERIAL	93
XII.	ENDOGENOUS POISONS	98
XIII.	PSYCHIC AND SOCIAL FACTORS	103
	PART III. SPECIAL DEGENERATIVE DISEASES	
XIV.	DEGENERATIVE DISEASES OF THE ARTERIES	111
XV.	DEGENERATIVE DISEASES OF THE HEART	136
XVI.	THE CHRONIC DEGENERATIVE DISEASES OF THE KIDNEYS	165
XVII.	DEGENERATIVE DISEASES OF THE DIGESTIVE APPARATUS	177
XVIII.	DEGENERATIVE DISEASES OF THE NERVOUS SYSTEM	198
XIX.	DEGENERATIVE CONDITIONS OF THE LOCOMOTOR APPARATUS, THE BONES, THE JOINTS, AND THE MUSCLES	222
XX.	DEGENERATIVE DISEASES OF THE ENDROCINE GLANDS	232
	INDEX	243

PREFACE

We have been requested by the editor, Dr. Allan J. McLaughlin, to prepare this volume as one of a Public Health Series, designed for that highly intelligent group of people made up of physicians, lawyers, clergymen, teachers, social workers, clubwomen, business men, business women, and others who are leaders of thought and of opinion in their communities and who have not the time to read and to digest technical books on outside subjects. This Health Series is based upon the view that there is a need for books for the use and for the education of this important group.

There has been no attempt to make the subject-matter complete or technical. We have tried rather to state comparatively simply and briefly the present-day conception of the causes of the chronic diseases of later life and to indicate some of the methods by which they may be prevented or their onset deferred.

In writing the book we have made free use of current medical literature and we acknowledge our indebtedness to many authors, some of whom have been mentioned in the text.

L. F. B.
T. P. S.

PART ONE

GENERAL CONSIDERATIONS

THE DEGENERATIVE DISEASES: THEIR CAUSES AND THEIR PREVENTION

CHAPTER I

INTRODUCTORY

MEDICAL science and the biological sciences contributory to it have made great strides during the past century. Much more is known now about the causes of diseases and the methods of preventing them than was known a hundred years ago. Some insight has been obtained into the physico-chemical changes of living matter, and into the intricacies of the human machine so much more wonderful and more complex than any of man's devising. We are beginning to have a better knowledge of the origin and of the development of the individual and of the factors that make him what he is. This increase in organized knowledge is of the greatest assistance in the study of preventive medicine in general; and much of the new knowledge can be applied to the prevention of those diseases of later life that are known to be dependent upon a wide variety of factors.

Since the advent of bacteriology a half century ago great progress has been made in the prevention of the infectious diseases. The morbidity and the mortality from diseases like typhoid fever, diphtheria, and tuberculosis have been diminished very markedly. On the other hand, very little interest has, until recently, been shown in the attempt to prevent the functional and structural diseases of the arteries, of the heart, of the kidneys, and of the brain that occur in middle and advanced life—indeed, but little has, as yet, been accomplished in this direction. Mortality statistics in the

United States seem to indicate that, instead of diminishing, the death rate from these causes is steadily increasing. It is with these degenerative diseases that this volume will deal; in it we shall discuss particularly the diseases induced by a gradual deterioration of an organ or tissue that, unchecked, leads to similar changes in other organs and tissues and tends to progress to a stage incompatible with the continuation of the life of the individual. Death by one of these diseases may, in a certain sense, be considered as the natural death of an individual or the wearing out of the human machine, as opposed to accidental death from traumatic injury or bacterial infection.

The idea of the wearing out of machines is perfectly familiar to all of us; indeed, it is axiomatic. No one has yet succeeded in producing perpetual motion, although there have been many ill-considered announcements of success. The human machines, or, for that matter, other animal machines, are of extraordinary complexity, and man-made instruments pale into insignificance when compared with them. It is true that a few fine watches and clocks may run for many years if carefully wound up at regular intervals and their parts occasionally separated, oiled, and rebuilt into the whole article, with once in a while the replacement of important parts. The animal machine runs incessantly, and even during its period of most nearly complete rest—that is, during sleep—many of its parts are actively working. Scientists have been experimenting with living creatures for a long time, but no one has ever been able thus far to create life. Life itself is a *continuum;* it has "gone on" from generation to generation ever since it first appeared upon the globe. Living creatures die, but life itself continues. Scientists know nothing of the origin of life, but the inauguration of a new individual and its development from preceding living forms are beginning to be understood.

It is an interesting biological fact that among the lowest animal forms, the tiny animals consisting of but a single cell, death does not necessarily occur. Accidental death

occurs, of course, but natural death from the wearing out of the organism need not occur if the surroundings are favorable. These tiny organisms, for example, the *Amœbæ*, when they reach a certain size, simply divide, each one into two smaller animals that go on living and growing. When they in turn reach full adult size they again divide into two other forms, and so on indefinitely. They may, therefore, be considered as potentially immortal.

Among the higher animal forms reproduction is a much more complex affair. Certain cells of most unusual potentialities are set aside for purposes of reproduction. These germ cells in the female are spoken of as the ova, and in the male as the spermatozoa. For the inauguration of a new individual, as a rule, there must be a union between two germ cells of opposite sexes in such a way that each germ cell gives to the new individual an approximately equal amount of inheritance material. It is, however, possible in some of the lower forms of life to start the development of a living creature by artificially stimulating one or the other germ cell without the union of the two. The usual method of reproduction is spoken of as sexual, since it is the function of the spermatozoon of the male to stimulate the ovum of the female to development. The second and unusual method is called parthenogenesis—asexual or virginal reproduction. This occurs spontaneously under some conditions in certain forms of life and it may also be brought about artificially in the laboratory.

From the fundamental standpoint of life the germ cells of the higher creatures in the animal scale are also potentially immortal, and it is through the continuity of their existence that life is carried on from generation to generation. From this standpoint all the cells of the body are divisible into two portions, the germ cells and the soma cells. Our bodies consist chiefly of the soma cells, which go to make up the different organs and tissues that are so widely diversified for different purposes. The whole body is therefore spoken of as the "soma."

In the smallest animal forms, the single-celled organisms, there is no differentiation of cells into germ cells and soma cells, all the functions of life being carried on by the single cell that constitutes the whole organism. In the higher forms of the animal kingdom only the germ cells retain the potential immortality of the unicellular organisms, the soma (with all the somatic cells) dies, if not an accidental death, then a natural death from some degenerative condition toward the end of the life span for that species. The questions why living things die and why they die when they do, have greatly interested biologists. We have seen that the germ cells possess a potential immortality. It has also been shown experimentally that the somatic cells, or some types of them, at least, also seem to possess a potential immortality. Thus, during the past fifteen years a great deal of work has been done on the artificial culture of cells and tissues outside of the body. The work of Loeb, of Harrison, of Carrel, and of others has shown that it is possible, under aseptic precautions, to take small pieces, small masses of cells or tissue, from the different organs of the embryonic or of the adult body of different types, to place them under suitable environmental conditions of food and temperature, and under the microscope to watch them grow, multiply, and divide; in some instances they show evidence of the function of the organ from which they were taken. Carrel has been able to keep cultures of tissues from a part of a chick embryo alive for a long period of years—for a longer period, in fact, than the normal duration of life of the species from which the cells came. Small portions of these cultures have been repeatedly subcultured—that is, they have been placed in a new environment with a new food supply. These cells are not only still living, but they give every evidence of vigorous active growth, and presumably, if the cultures are carefully tended, they may go on living for any number of years.

In spite of the fact that these experiments seem to show that the somatic cells, as well as the germ cells, may go on

living, multiplying, and regenerating indefinitely when removed from the body and placed under favorable conditions, we nevertheless know that the body as a whole does not possess this power, but degenerates and dies at the end of the life span of the species. It may be assumed that through extreme differentiation and specialization of function the power of regeneration has to a certain extent been lost by many of the important body cells and tissues, and the failure of some organ or part to continue in its normal harmonious functioning brings about the functional breakdown of other dependent parts of the body.[1]

The duration of life, or the time at which natural death of an animal occurs, is determined to a great extent by its inherited physico-chemical constitution. We know, for instance, that the life span of some forms of life is only a few hours. Certain insects live for about three months. The horse may live for thirty years or more, and man for seventy to one hundred years. Within each species there are different strains with different inheritance in respect to the duration of life, and this is of some importance in human beings, as we shall point out in later sections. It may be said that each species, or each strain, has a certain inherited endowment in this respect and that the use of this endowment depends to a certain extent upon the environmental factors with which the individual comes in contact. As we shall point out later, the environment is more important in man's development than in that of the lower forms of animal life.

It will be our endeavor in this book to point out some of the causes of the degenerative conditions that bring man's life to an end and to indicate methods by which it may be possible, to a certain degree, to obviate these factors and thus to promote one's longevity and to prolong one's period of usefulness and comfort.

1 The reader who is interested in the fundamental biological considerations of life and death is referred to Raymond Pearl's interesting book, *The Biology of Death*, published by J. B. Lippincott Co., 1922.

CHAPTER II

GENERAL DISCUSSION OF THE CAUSES OF DEGENERATIVE DISEASES

Disease and death are usually the result of the interaction of a number of causative factors. In the relatively rare instances where a single cause may be blamed, the disease or death is accidental and usually of a violent type, as, for example, when one is struck by lightning, suffers a gunshot wound, or is injured in a railway or automobile wreck. The natural human tendency in the presence of any affliction, whether it be a headache, a stomach ache, a lame back, or what not, is to look back over the recent past in the search for some single incident to which the trouble may be referred. People fail to realize that, even with minor ailments, a number of different factors, internal and external, have probably been at work. In order that these different factors may receive the proper consideration it is customary to divide the causes of disease into two main divisions, (1) the *predisposing causes* and (2) the *direct* or *exciting causes.*

During the past century, the chief interest of scientific medicine has been directed toward the external sources of disease, the direct or exciting causes, which are more nearly susceptible of mathematical analysis and ascertainable by the application of methods of precision. This interest has been extraordinarily fruitful and rewarding in the development of bacteriology with the consequent knowledge of sepsis and asepsis, which has made possible the triumphs of modern surgery; in advances made through the study of parasitology and of immunology, which have led to the

virtual conquest of small-pox, of diphtheria, of yellow fever, and of certain other specific infections; and in the great improvement in chemotherapy or drug treatment of certain infectious diseases. All the while, however, physicians have been impressed fully as much with differences in susceptibility to disease, differences in predisposition, differences in powers of resistance to external factors, and differences in rapidity and completeness of recovery from disease or injury, as they have been with differences in the external causes themselves. They have asked themselves such questions as these: Why does one child exposed to measles become ill and another remain well? Why do active symptoms of tuberculosis frequently follow an attack of measles in a person previously apparently healthy? Why does John Doe, though a moderate drinker, develop hardening of the liver, whereas Richard Roe, a much heavier drinker, escapes? Why are there many suicides in one family and none in another? Why do the members on one family live to be over eighty years of age while the members of a neighboring family, living under similar conditions, die at fifty of apoplexy or of heart trouble? Obviously there are many internal differences in persons as well as external variations. Human beings resemble one another, but each differs from every other. Each person is unique. How does a given person, so like others and yet so different from others, come to be what he is?

During the past two or three decades, thanks to exact studies of heredity and of development, the scientific foundations for a general and special pathology of constitution and predisposition have been laid. Biologists, who during the previous century had concentrated their attention upon the origin of species (doctrine of evolution), have in the present century directed their researches more particularly to the origin of individuals (phenomena of inheritance and development). Through experimental studies of heredity and development in animals and plants they have accumulated data and established principles that are full of promise for

a better understanding of human heredity and development, for there is every reason to believe that the development of a human being resembles in all essential respects that of other animals. Man, like the chicken or the rabbit, begins through the union of two sex cells or germ cells, an egg cell (ovum) from the mother and a fertilizing cell (spermatozoön) from the father. These two cells, fused to form a single cell (zygote), start a new individual, which in a suitable environment subdivides into two cells, then into four, and then gradually into many millions of cells with concomitant multiplication and differentiation. This new individual develops stage by stage, first as an embryo within the mother's womb, later as a child within the home, still later as a boy or girl in the school, and finally reaches adulthood, entering into manifold relationships with the larger world of society. In these successive stages of human development and differentiation we have to deal with two sets of factors: (1) those of the germ plasm derived from the father and mother (factors of heredity), and (2) those of the surroundings of the developing being (factors of environment). The factors of heredity offer certain possibilities of development (and no others); among these possibilities of development, those actually come to fruition that are brought there through the influences of the factors of the environment (physical, chemical, psychical, and social). The heredity of the individual has determined the *possibilities* of his development; the surroundings during development have been decisive as to the possibilities that have attained to *realization*. The fertilized germ cell represents through its nuclear material the inheritance uninfluenced by environment. It begins, however, immediately to be influenced by its surroundings and to undergo changes as a result. If development proceed normally, the reactions between the germ plasm and the environment gradually lead to the fully developed organism, in man the "realized adult person." To this realized organism the term "phenotype" has been applied, whereas to the germinal material with

all its hereditary peculiarities has been given the name "idiotype" or "genotype." Now the genotypic part of a phenotype—that is, the part due to heredity—may be designated "constitution," whereas the rest of the phenotype, the part of it due to environmental influences, may be called "condition." The phenotype (realized adult) is, thus conceived, the resultant of the interaction of "constitutional" factors with "conditional" influences. Sometimes the term "constitution" is used in a broader sense and we then speak of the total constitution (phenotype) as consisting of two parts: (1) an inherited portion of the constitution (genotype), and (2) an acquired portion of the constitution (paratype or condition).

Considerable variation in human beings is compatible with health, though each variation may entail some special individual predisposition to disease, since the variation may limit the readiness with which the person adapts himself to his environment. The study of "personal variants" becomes, therefore, of great importance, for an acquaintance with these and their corresponding dispositions to disease will be essential for the development of methods of special as contrasted with general prophylaxis. Personal variants may be of the morphological type, exhibited in differences in physical configuration (habitus), or they may be of the functional type, manifested in differences in biochemical composition or in differences in modes of reaction. Further, there are evolutive and involutive personal variants characterized respectively by differences in times of reaching full development and in times of appearance of the changes of senescence. A morphological variant exhibiting an "asthenic habitus" is believed to be, other things being equal, more susceptible than others to pulmonary tuberculosis; a functional variant who metabolizes or excretes purins (forerunners of uric acid) slowly is in danger of paroxysms of gout; an evolutive variant who carries his infantile or adolescent modes of reaction and adaptation into adulthood runs the risk of psychoneurotic failure of social adaptation; and an

involutive variant who shows an early baldness, an early arcus senilis of the cornea, or a premature menopause may, a little later on, show other signs of a partial or universal senilism or, in other words, become the subject of a pathological abiotrophy, a premature degenerative disease of the purer type.

Disposition to disease in a given person may depend upon abnormalities of the inherited constitution (genotype) chiefly, upon abnormalities of the acquired constitution (paratype) chiefly, or upon a combination of both. An example frequently chosen for illustration is pulmonary tuberculosis. From the standpoint of inherited constitution, a person with a long, narrow thorax and voluminous lungs (*habitus asthenicus*) is believed to be much more liable, other things being equal, to progressive pulmonary tuberculosis than is a man with short neck and thorax and small lungs (*habitus apoplecticus*). From the standpoint of acquired constitution, a person who has recently recovered from measles or whooping cough is, other things being equal, in greater danger of pulmonary tuberculosis than is another. A person with asthenic habitus convalescent from measles has a combined inherited and acquired predisposition to pulmonary tuberculosis and is accordingly doubly endangered. In the example just cited, other predisposing causes of the non-inherited type may be operating at the same time, as, for instance, malnutrition, poor ventilation, social ills of other sorts, excessive fatigue and constant exposure to infection. The *exciting cause* of the disease is, of course, the tubercle bacillus.

The causes of the degenerative diseases are probably more complicated than those of any other type. We have seen above how varied may be the influences leading to the development of an infectious disease like tuberculosis. Degenerative diseases occur, as a rule, in later life, after the person's inherited constitution has been subjected to many years of conditional influences. The person may have begun life with a constitution of average type, which was grad-

ually undermined by bad social conditions, physical injuries, infectious diseases, chemical poisons and overwork, a combination that would tend to use up his vital patrimony relatively early and subject him to the danger of a degenerative disease prematurely. On the other hand if he has been endowed with a very strong and long-lived inheritance, he may live to a ripe old age though engaged in very hard work all of his life and addicted to the excessive use of tobacco and alcohol. Indeed, it is not uncommon to hear of old men of this type attributing their longevity to the use of tobacco, to their numerous toddies, or to the fact that they had worked incessantly. Such claims, of course, are absurd; they live to be octogenarians because of their strong inherited constitutions and in spite of the potentially harmful conditions to which they were subjected. It may be very easy in certain cases to determine the basis (genotypic or paratypic) of a degenerative condition; thus the tendencies to amaurotic family idiocy, Friedreich's ataxia and Huntington's chorea, are inherited, and it is altogether probable that no environmental conditions, however favorable, would be able to prevent the onset of symptoms at the usual time. On the other hand, the decision as to the actual causes of certain degenerative diseases may be very difficult. A man may come of apparently good stock and in his early life enjoy good health, and yet die in middle age after wasting his patrimony by all sorts of excesses of work and of play. One might say at once that in such a case the environmental factors were responsible for his early death, and so they may have been in large measure; yet, the will to live at a high rate of speed and the ability so to live may be, in many cases at least, inherited characteristics of the nervous system and so to a certain extent beyond control in the absence of proper early training. Since, in the etiology of degenerative diseases in general, the possibilities are as wide as our knowledge of heredity and of environment can be, it is easy to understand how, in the enumeration of environmental factors considered harmful, the same ones may be repeatedly men-

tioned in connection with different degenerative states, the patient's predisposition (constitutional and conditional) determining the organ system or tissue first affected by the degenerative change.

One of the purest forms of degenerative states is the condition that we speak of as "senility," which may be defined as the gradual breaking down and wearing out of all the organ systems of the body contemporaneously. Probably in the strictest sense this occurs relatively rarely, for as a rule one system is at first more markedly involved than others and the results of its changes inaugurate those in the other systems. We are all familiar with the outward appearance and behavior manifested by the senile—*e. g.*, the bent posture, the gray or bald head, the wrinkled skin, the slow and difficult movements, the slowness of thought, the loss of memory, especially for recent events. Besides these obvious changes, pathologists describe a reduction in the size of many of the inner organs; an increase in the fibrous connective tissue within the organs; an atrophy and brittleness of bones; an atrophy of the so-called elastic tissue (which is an important constituent of the skin, of the arteries, and of the lungs); and certain cytological changes or alterations within the individual cells. Biologists are not, as yet, in accord with respect to the fundamental basis of senility. The cytological changes emphasized as primary by some authors are considered by others to be really effects or concomitant features rather than the causes of senescence.

Among the various hypotheses that have been suggested is the assumption that senility is due to a loss of power on the part of the cells to regenerate. This view would seem to be refuted by the work of Carrel, who has been successful in the artificial cultivation outside of the body of cells for a longer period of years than the usual duration of life of the species from which they were taken. The fact that these cells are still vigorous in their growth and show no signs of senescence indicates to many biologists that the basis of senility is not inherent in the cells. Other experiments by

Carrel and Ebeling show that there are changes in the blood serum in old animals. They found that the rate of multiplication of fibroblasts (young connective tissue cells) *in vitro* and the duration of life in such cultures is inversely proportional to the age of the animal from which the serum for the culture medium is taken. These results suggest that there is produced in some cases by the body or some of its parts, as the animal grows older, a substance that inhibits the power of cells to multiply or to remain alive. Pearl prefers to interpret their results "on the supposition that the serum from an old animal is itself senescent as a whole; that is, has undergone a physico-chemical alteration (as compared with that of a young animal), which is comparable to the morphological and physiological changes that are observable in senescent cells. It may further quite reasonably be supposed that 'senescent' serum, because of these physico-chemical alterations, does not furnish as favorable a nutrient medium for *in vitro* cultures as does 'young' serum. Such a view avoids the necessity of postulating a specific 'senescent' substance, the existence of which would be exceedingly difficult to prove."

We have stated above that usually a more or less pronounced degenerative change occurs first in some one tissue or organ system, and that the malfunctioning of this system inaugurates changes in other related organ systems until the whole body structure is affected. We have further intimated that one of the tissues that atrophies relatively early is the elastic connective tissue. This elastic-tissue atrophy in the skin is manifest in the wrinkling and loss of elasticity of the integument so familiar in the aged. In the lungs the loss of this constituent effects a diminution in the respiratory surface area, a general loss of elasticity, and ultimately may cause a condition spoken of as emphysema of the lungs. The most far-reaching effects of elastic-tissue atrophy are seen in its results in the arterial system of which this tissue is a prominent constituent and elasticity an important function; hence, the saying that "one is as old as one's arteries"

contains more than a grain of truth. The gradual loss of the elastic tissue and the subsequent changes in the arterial wall affect the structure and functions of this life-carrying system and may bring about a number of different diseased states, owing to the facts that some portions of the arterial tree may be much more affected than others, and that the organs supplied with blood by these portions, suffering under the poor nutrition, give rise to the dominant symptoms shown by the patient. When the kidneys are most affected, the patient presents the symptoms of chronic Bright's disease and may die of uremic poisoning; when the brain suffers most by the arterial changes, apoplexy, softening of the brain, or other abnormal mental and physical states may ensue.

Obviously, from their nature, the degenerative diseases of senescence cannot be prevented except by the barbarity of destroying life before this stage has been reached. Indeed, one ideal of preventive medicine might be to prevent all other diseases and to permit all men to die in the fullness of years a "natural" death from some degenerative condition. The problem of hygiene in regard to this field is to postpone the inauguration of the degenerative change, to retard its progress, to avoid, if practicable, certain expected complications, and to promote as far as possible the comfort of the patient.

There are other types of degenerative diseases that apparently have nothing to do with senescence and which may even begin characteristically in youth, as for example the so-called multiple or insular sclerosis of the nervous system. In some of these maladies, as in the example cited, the etiology is still obscure and the direction for hygienic effort correspondingly befogged; in others, as in tabes dorsalis (locomotor ataxia), where an important etiological factor is known, intelligent scientific preventive methods can more easily be instituted.

CHAPTER III

THE RELATION OF HEREDITY TO HEALTH AND DISEASE

We have already emphasized to some extent the importance of heredity in the development of the individual and in his ability to resist disease. All hypotheses concerning the origin of species (evolution) and of the origin of individuals (development) must be based upon heredity and, as more light is shed upon this formerly dark and confused subject, these hypotheses must be changed to accord with the newly discovered facts; gradually the hypotheses develop into theories as the facts accumulate to support them. For instance, biologists no longer believe with Lamarck in the "inheritance of acquired characters"; they have shown that, although rats' tails may be cut off for many generations, yet the young rats continue to be born with tails. The blacksmith's son does not inherit the brawny right arm of his father, but must work for it himself. Furthermore, biologists do not think of developed qualities and characteristics of any sort being transmitted as such from parent to child, like stocks and bonds or real estate. This "legal or property conception of inheritance" must not be confused with the biological concept in which we think of the germ cell as containing factors, determiners, or possibilities, of certain traits that must be developed with the aid of environment in order to come to fruition. We must recognize the facts (1) that the adult bodies of the parents do not produce the germ cells that later become their children; (2) that the forerunners of these germ cells are derived from the germ cells that developed into the parents' bodies and were at an early stage of that development set aside to carry

on the life of the race; (3) that these cells, so set aside, are *in* the body (the soma) of the adult parent, but, in a certain sense, not *of* it, for they are practically unaffected, as far as inheritance is concerned, by the vicissitudes to which the soma is subjected. Germ cells develop into (1) somata and (2) other germ cells. These germ cells develop in turn into (1) somata and (2) other germ cells. The germ cells form a continuous stream of life from which the somata are discontinuous offshoots that develop, live their allotted span, degenerate and die. The germ cell before undergoing development must unite with another germ cell of the opposite sex, thus introducing new factors of inheritance in almost infinite variety.

Though it is generally agreed that "acquired characters are not inherited," it is admitted that the germ cells, along with the body cells, may be damaged by certain harmful environmental conditions, as for example, poor nutrition, extremes of heat or cold, or chemical poisons. The adult structures developed from such injured germ cells may show evidence of the damage for one or two generations, but subsequent generations return completely to the normal status. This phenomenon, spoken of as *induction,* is not an evidence of true heredity. Certain plants when grown in very poor soil will be stunted in their growth and seed from these plants may produce stunted plants regardless of the soil in which they grow, but in the third generation the developed plant will again be quite normal. There have been described in several animal species similar deleterious effects of alcohol that persisted through two or three generations. Biologists believe that sometimes from environmental influences changes occur in the germ cells that may be permanent (so-called idiokinetic changes) and that the character resulting therefrom may be transmitted according to the usual laws of heredity.

Knowledge of heredity has made great progress since biologists began to study the traits or constituent characters of organisms *singly,* instead of limiting their attention to

resemblances and differences of whole organisms considered as indivisible units. The characters or traits that distinguish the genus, the species, the race, are all inherited; they are firmly fixed by heredity. Many individual characters (structural and functional) are also known to be hereditarily determined; others are due to environment and are not determined by heredity. The modern knowledge has been and is being obtained by several methods: (1) the experimental breeding of plants and animals, (2) the study of germ cells, of the process of fertilization, and of the growth and differentiation of young organisms by cytologists and embryologists, and (3) the application of mathematical methods (statistical methods) to the determination of relations among the phenomena under study. Francis Galton was a pioneer worker with the third method and is considered the real founder of the scientific study of inheritance. He studied characters singly and introduced the use of quantitative measures.

A new light was thrown upon the subject through the elucidation of certain principles by means of the experimental method by Gregor Mendel, whose work on *Experiments in Plant Hybridization* was published in 1866, but was generally lost sight of until his facts were rediscovered by de Vries and other botanists in 1900. These workers and their followers believe (1) that certain characters are inherited as a whole and are not further subdivisible (*principle of unit characters*), (2) that when contrasting unit characters are present in the two parents, one becomes dominant and the other recessive in the offspring (*principle of dominance*), and (3) that every single germ cell is "pure" as regards any given unit character, even though it be derived from a hybrid parent (*principle of segregation*).

A brief summary of some of Mendel's work will serve to illustrate these principles. He hybridized some twenty-two varieties of garden peas, devoting his attention to seven of the differentiating characters that distinguished the varieties and following them through several generations. When he

crossed a variety having tall stems with a variety having short stems he found that the plants developing from such a cross possessed tall stems. The tall-stemmed character was dominant over the short-stemmed character, which became latent in this generation. When these hybrids were self-fertilized some of the individuals of this second filial generation showed the dominant trait with long stems and others the recessive trait with short stems in the proportion of approximately three dominants to one recessive. These recessives, when self-fertilized, were found to be pure in that they produced recessives indefinitely. One-third of the dominants were also found to be pure dominants, and these pure offspring of hybrid parents were spoken of as "extracted" recessives and "extracted' dominants. Two-thirds of the dominants of the second filial generation, when self-fertilized, were found to be hybrids and gave rise in the next generation to pure dominants, mixed dominant-recessives, and pure recessives in the proportion of 1 : 2 : 1.

In the phenomenon known as "incomplete dominance" the hybrids differ from either parent, as when a white-flowered variety of *Mirabilis,* the "four-o'clock," is crossed with a red-flowered variety. All the hybrids in the first filial generation have pink flowers and these give rise in the next generation to white-flowered, pink-flowered, and red-flowered forms in the proportion of 1 white : 2 pink : 1 red.

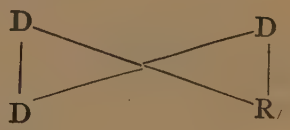
The establishment of the principle of segregation, or the "purity" of germ cells in regard to any unit character, is a very important part of Mendel's work. All the germ cells of the red four-o'clock contain the factor for red, and all the germ cells of the white four-o'clock contain the factor for white. When these two are crossed a pink hybrid results, but in the germ cells of this hybrid there is no factor for pink; the germ cells formed by the hybrid contain the factor for either red or white, but no single germ cell contains both red and white. Among the numerous germ cells formed by the hybrid, those carrying the factor for white occur in approximately the same number as those carrying the factor

for red. When these germ cells unite with each other, the matings of white with white give white flowers, red with red the red flowers, and the red with white produce the pink hybrid flowers again. The mathematical probabilities of these unions explain the extracted dominants, the extracted recessives, and the mixed dominant-recessives as well as their relative numbers. This typical Mendelian ratio may be illustrated by the following diagram:

Possible combinations: 1 DD : 2 D (R) : 1 RR

(1 pure dominant : 2 dominant-recessive : 1 pure recessive)

There are other simple Mendelian ratios, as when a pure dominant is crossed with a mixed dominant-recessive all the offspring show the dominant character, though one half are pure dominants and the other half dominant-recessive.



Possible combinations: 2 DD : 2 D(R).

When a pure recessive is crossed with a mixed dominant-recessive, dominants and recessives appear in equal numbers:

Possible combination 2 D(R) : 2 RR.

As Conklin [1] points out, this ratio of 2:2 or 1:1 is approximately the ratio of the two sexes in many animals and plants,

[1] Conklin, E. G., *Heredity and Environment in the Development of Men*, third ed., Princeton, N. J., 1919, Princeton Universal Press.

and there is good reason to believe that sex is a Mendelian character of this sort, in which one parent is heterozygous (hybrid) for sex and the other homozygous (pure).

In arranging such experiments it is possible, of course, to consider one or more pairs of contrasting characters at the same time, the offspring being considered as if they were monohybrids, dihybrids, trihybrids, or, in case more than three pairs of contrasting characters are considered, polyhybrids.

In order to understand some of the later modifications of Mendelian ratios, it is necessary to recall that factors of inheritance are not undeveloped characters, but must be considered differential causes or determiners of characters. It is possible that two or more factors may be concerned in the production of a single character with corresponding increase in the complexity of the mechanism. Such combinations are now used to explain those forms of inheritance which were formerly supposed to differ materially from the Mendelian type.

Further light has been thrown upon the problems of heredity by the study of the germ cells and of the early development of the zygote that is formed by their union. The cell is the structural unit of living matter, the smallest portion that is capable of independent existence and which shows the fundamental properties of living substance. The cell consists essentially of a cell body in which there is a nucleus that can be differentiated by its peculiar staining reactions with the dyes used in the microscopic study of cells. This nuclear substance with the special affinity for dyes is called on this account "chromatin" and under certain conditions, notably in cell division, it is divided up into irregularly shaped rods or threads, which are called "chromosomes." The number of chromosomes is constant for every species and race and the cells of the adult body contain twice the number of chromosomes found in the corresponding germ cell. Thus, in a species containing forty-eight chromosomes in each cell nucleus as in man, twenty-four of these come from the fe-

male germ cell and twenty-four from the male germ cell. When the germ cells for the next generation are made the number of chromosomes is again reduced to twenty-four. When this reduction occurs, the chromosomes behave more or less independently, the same number going into each new cell, but not dividing up in the same way in the formation of the numerous germ cells. The possible different combinations in the species having twenty-four chromosomes in the germ cell and twenty-four pairs or forty-eight in the adult cell would be $(2)^{24}$, or 16,777,216. Since the possible number of different combinations in the germ cells is the same in each of the sexes, the possible number of different combinations of spermatoza with ova to form the zygote with potentialities for development into a new individual is $(16{,}777{,}216)^2$, or approximately three hundred thousand billions. Most biologists are now convinced that the inheritance factors are located in the chromosomes, whose behavior exactly parallels that of the hereditary factors in Mendelian experiments. With this fact in mind it may be readily appreciated how infinitely varied are the possibilities of heredity even among children of the same parents, and the trite observation that no two men are alike finds a ready explanation from the standpoint of heredity alone, disregarding for the moment the influence of environment in the development of the realized adult person.

Among other results of the experimental and cytological study of heredity may be mentioned the beliefs (1) that the sex-determining factor resides in a chromosome; (2) that many characters are linked together in inheritance, their determining factors being carried in the same chromosome; and (3) that some of these linkages of characters are associated in a definite and peculiar way with sex, a phenomenon that is known as sex-linked inheritance. An example of sex-linked inheritance in man is found in the abnormal condition called hemophilia, which is characterized by a deficiency in the clotting power of the blood and is therefore associated with excessive bleeding even from slight injuries

The unfortunate victims are almost always males, though the defect is always transmitted to a son from his mother who does not, as a rule, show the defect because it appears in females only when both parents were affected.

The study of inheritance in man is less satisfactory and less accurate than similar studies in lower forms, for man is a slow-breeding polyhybrid, has few children, and is relatively inaccessible to experiment. But there is in man, as in animals, a cellular basis to heredity, and in man the same distinction between germ cells and soma cells can be made. Furthermore, similar chromosome mechanisms are concerned, the inheritance of certain unit characters is similarly sex-linked, and mutations likewise occur and are inherited. We can feel tolerably certain, therefore, that the general principles of heredity and development that have been and are being established through animal experiment are broadly applicable to man and can safely be used as foundations in the study of man's development and of his predisposition to disease.

We have already mentioned the difficulty in distinguishing what is due to heredity and what is due to environment in the development of man. Biology teaches us the overwhelming importance of heredity in the development of lower forms of life, and, though it recognizes the much greater possibilities of human development and the infinitely more varied environmental conditions of that development, it leads us to believe that, with us also, heredity is the predominating factor in making us what we are. We know that heredity determines that the union of human germ cells leads to the development of a human being and not to that of a monkey or a horse. We know that heredity determines our race, our sex, our color, the color of our eyes, the nature of our hair (whether curly or straight); we believe that it determines in large measure our stature, the shape of our features, our native mental endowment, our possibilities of longevity, and hence our resistance or susceptibility to many forms of disease.

Are diseases inherited? Again let us say that no developed characters are inherited as such, but that our germ plasm may contain the determiners of certain abnormal traits as well as of normal traits, and that some of these abnormal traits constitute disease in that they render us less capable of living in harmony with our surroundings. Davenport and Plate have catalogued over sixty pathological human traits that they believe to be inherited in Mendelian fashion. Some of these appear to be dominant, some of them recessive, and a number of them, like hemophilia and color blindness, seem to be sex-linked. The clinical physician will readily accept many of these traits as hereditary—*e.g.,* achondroplasia (an abnormal development of cartilage producing dwarfs with short limbs, but with bodies and heads of normal size); Friedreich's ataxia; Huntington's chorea; hemophilia; and Daltonism (a form of color blindness). Concerning others —*e.g.,* multiple sclerosis, Sydenham's chorea (St. Vitus' dance), muscular atrophy; diabetes insipidus and diabetes mellitus—medical teaching is less confident, regarding them still as of obscure etiology.

More interesting because more important, though less easily studied, is the development of constitutional traits, based upon heredity, which predispose the individual to certain diseases, even though the exciting causes of these diseases may be definitely extraneous (environmental) in origin, as, for example, diphtheria, measles, tuberculosis, other infectious diseases, those caused by chemical poisons, etc. We know that infectious diseases as such are not inherited. They do not occur in the absence of the specific infective agent. Nevertheless, the inherited constitution has a great deal to do with resistance or susceptibility to infection, with the probability of death from the disease or of a rapid or a tedious convalescence. The inherited constitution may determine whether the effects of an infection can be entirely recovered from or whether the disease will leave its mark upon the arteries, upon the joints or upon the nervous system, thus contributing to their degeneration. Of

two bartenders (or bootleggers), who too assiduously sample their own wares, one may develop a chronic mental disease characterized by visual and auditory hallucinations, pseudo-reminiscences and neuritis with partial paralysis, whereas the other may sicken and die of hardening of the liver (cirrhosis) and show no sign of mental impairment. The constitution determines the type of reaction of the body to the poison, and the hereditary portion of the constitution is probably of very great importance in such cases.

An excellent example illustrating the importance of heredity for the degenerative diseases in general is to be found in the investigations concerning longevity, including the biometric studies of human beings and the experiments that have been made upon lower forms of life. Pearl gives an interesting account of the work of Dr. Alexander Graham Bell in this connection, in his study of the Hyde family, the genealogy of which had been so carefully compiled by Walworth. By analyzing the statistics in several different ways it was shown that there is a definite and close connection between the average longevity of parents and that of their children. By one table it was demonstrated that where neither parent lived to be eighty, only 5.3 per cent of the offspring lived to be eighty; where one parent, but not the other, lived to be eighty, 9.8 per cent of the offspring lived to be eighty; where both parents lived to be eighty, 20.6 per cent of the offspring lived to the same great age. Another table showed that the average age of persons whose parents both died under sixty years of age was thirty-two and eight-tenths years, while the average age of persons whose parents both lived to the age of eighty or over, was fifty-two and seven-tenths years. "In other words, it added almost exactly twenty years to the average life of the first group of people to have extremely long-lived parents, instead of parents dying under age sixty. However the matter is taken, a careful selection of one's parents in respect of longevity is the most reliable form of personal life insurance." Pearl has compared these figures with those which might be ex-

pected if all that medicine and hygiene know to-day was put into reasonably effective operation and no one died from any cause that we have reason to believe could be avoided. The total increase in expectation of life to be expected under these circumstances he gives as just under thirteen years. "No more striking demonstration could be found of the overwhelming importance of heredity in determining duration of life. For if all the deaths which reason will justify one in supposing preventable on the basis of what is now known were preventable in fact, the resulting increase in expectation of life falls seven years short of what might reasonably be expected to follow the selection of only one generation of ancestry (the parental) for longevity." Bell's work is supported by the somewhat similar statistical studies of Pearson, Ploetz, Snow, and others.

Pearl's experimental studies on the inheritance of duration of life in *Drosophila,* the common "fruit" or "vinegar" fly, emphasize the importance of heredity even more strikingly. They prove (1) that there are well marked hereditary differences in different strains of the same species of *Drosophila* with respect to duration of life, and (2) that the duration of life in *Drosophila* is inherited essentially in accordance with Mendelian laws, thus fitting in with a wide range of other physical characters of the animal that have been thoroughly studied by Morgan and others.

If heredity is of such great importance in the determination of the duration of life, it must obviously be of equal importance for the consideration of the degenerative diseases that bring life to an end.

CHAPTER IV

THE RELATION OF ENVIRONMENT TO HEALTH AND DISEASE

In discussions concerning the relative importance of heredity and of environment, it should always be remembered that both are necessary for the development of an individual. Without the necessary environmental stimuli the fertilized ovum (zygote) would remain a single cell and no development would be possible. In the zygote there are factors or determiners—sometimes called "ids" or "genes" —which fix the possibilities of development; the traits or characters of the person are not there in miniature, but must be developed through environmental influences. Hence when we speak of a trait as of hereditary or of environmental origin, we mean that the differential or the determining cause of that trait is to be found in heredity or in environment, as the case may be. A hundred years ago the greatest emphasis was placed upon the importance of environment, and many of our institutions of to-day—social, political, religious—are based upon the assumption that all men are created equal and that the differences in men are due to the influences by which they have been surrounded. Now the pendulum has swung in the opposite direction and biologists are convinced of the overwhelmingly preponderant importance of heredity for the development of the lower forms of life and of its relatively great importance for the development of man. The hereditary factor is just as important for man as for the lower animals, but for man the environmental factor is much more important than it is for the lower forms. Man's period of helpless immaturity, during which he is most susceptible to the play of environ-

mental influences, is much longer than that of any other living creature; his possibilities of development are much greater; his environment is more varied; by the development of his intellect, his reason, and his will, he "chooses" his path to a certain extent and changes many features of his environment to his own benefit or detriment. Thus, though we must recognize the importance of heredity in our own development, we should not underestimate that of our environment upon the study of which almost all our efforts in hygiene and in public health hitherto have been based. What is environment? In the ordinary sense of the term in which it is defined from the standpoint of the entire organism, we mean all that lies outside the individual organism.[1]

Normal development depends upon the normal response of the germinal material to the usual environmental stimuli. Different stimuli may produce much the same response, as, for example, the different means by which artificial parthenogenesis may be induced; and the same stimulus may have quite different effects when exerted at different periods of an organism's development. The response to a physical or chemical stimulus by a germ cell before fertilization may differ decidedly from that of a developing zygote, and, similarly, the responses to various environmental influences may vary in infancy, in childhood, in youth, and in adulthood.

[1] The subdivision of "internal environment" is useful to denote the influences playing upon one organ or cell in the body and arising through the activities of other organs or cells within the same body, as may be seen, for example, in the effect of arterial changes upon the kidneys or upon the heart or upon the brain (but such "internal environment" should not be confused with the "environment of the organism as a whole"). Especially in early development, these intrinsic factors, the interaction of organs and cells upon each other, are important in correlating the growth of the whole organism, and, through the influence of abnormal intrinsic factors, the general growth may be stunted or severe defects of development be inaugurated, which may lead to the production of terrible monstrosities. These intrinsic mechanisms are partly of hereditary origin, partly of environmental origin. Often it is some extrinsic (environmental) factor that initiates the series of changes within the intrinsic mechanism.

Many experiments have been performed in studying the influence of environment upon early development. In some of these experiments certain stimuli that are usually present were eliminated, and in others stimuli not usually present were introduced. By such methods great changes in development may be brought about; animals in which whole organ systems are absent may be formed, or one-eyed or double-headed monsters may be produced. In general, it is now believed that most monstrous and defective forms of development are due to alterations of environment rather than to defective heredity, though certain relatively less serious conditions are known to be inherited in Mendelian fashion, as, for example, supernumerary fingers and toes and albinism (lack of normal pigmentation).

Although the germ cells within the body of the adult are in a sense especially set aside for the purposes of reproduction and are conveniently contrasted with the soma (all other cells of the body) for purposes of biological discussion, nevertheless they receive their nourishment just as other cells do and are subject to the harmful influences that may affect the body in general. Experiments have been performed to see what may be the results of damaging these cells, spermatozoa or ova or both, before their union to form a new individual. Monstrosities have been produced in this way by the action of various abnormal physical and chemical stimuli applied to spermatozoa.

Among the more interesting experiments of this type are those of Stockard and of Pearl, who studied the offspring of alcoholized parents. Both found that the germ cells are injured and that most of them die or the embryo dies soon after development begins. The stronger germ cells survive, but, according to Stockard, there is a great increase of stillbirths and of weak and sickly offspring. Pearl found the chicks of alcoholized parent chickens stronger than those from normal parents and attributed this to the fact that only the sturdiest survived, these only escaping injury. Stockard followed his guinea-pigs through the fourth generation and

found that the general injury persisted through two or three generations. Conklin and others have pointed out that in those experiments the animals were subjected to a much greater degree of alcoholic intoxication than is ever the case in man and that this fact must be taken into consideration in applying the results of these experiments to human beings.

As examples of the factors or stimuli that aid in bringing about our development and are of importance in the maintenance of health or in the production of disease we may mention the following:

1. *Physical factors,* including the mechanical (trauma, use, disuse, etc.); thermal; electrical; light; etc.
2. *Chemical factors,* including:
   (A) Exogenous factors (from without)
      (a) Normal stimuli, as food, water, air, etc.
      (b) Abnormal stimuli, as biological toxins from bacteria, animal parasites, protein intoxications and inorganic poisons like lead, mercury, alcohol, ether, tobacco.
   (B) Endogenous factors (from within)
      (a) Normal: so-called internal secretions; carbon dioxide and other products of normal metabolism.
      (b) Abnormal: perverted secretions; products of abnormal metabolism; accumulation of waste products which cannot be excreted.
3. *Psychic factors:* influence on development of the emotions, intelligence, memory, will, through the voluntary nervous system and through the involuntary or autonomic nervous system.
4. *Social factors:* poverty; luxury, social habits of work, play, rest, exercise.[1]

[1] The physical factors, the exogenous chemical factors, and the social factors are of environmental origin. The endogenous chemical factors and the psychic factors are due partly to environmental stimuli and partly to factors of inheritance.

Physical Factors.—We may emphasize again that the result of the action of any of these factors varies with the intensity of the stimulus and with the period of development of the individual on which it acts, as well as with other influences that may determine the receptivity of the developing organism. A given stimulus acting in a certain degree may be most useful for normal development and health, but, applied in some other way or in too concentrated a form, may be quite injurious. In early development the mere physical juxtaposition of parts is an important factor in orderly growth as transplantation experiments have shown. A relatively slight mechanical trauma may produce a serious malformation if applied to a very young embryo but the same trauma may produce insignificant effects if exerted at a later period of development.

The effect of use or disuse of a part is important. By frequent use a group of muscles becomes large and strong; if, on the other hand, a limb is immobilized in a cast, not only the muscles but the bone and other tissues undergo atrophy or shrinkage. Similarly, teeth which are given an adequate amount of work to do by the proper chewing of a satisfactory diet tend to become strong, while those which have little to do necessitate many trips to the dentist's chair.

It is well known that, owing to an extraordinarily efficient mechanism, the temperature of the body is maintained within remarkably narrow limits, so that the body can stand exposure to a very wide range of outside temperature, to as low (for brief periods) as 100° F. below the freezing point, and to as high as 260° F., which is about 50° F. above the boiling point of water. As Adami points out, this means that the body as a whole can be exposed to temperatures far beyond those at which protoplasm (of which it is made) is frozen, on the one hand, or undergoes heat coagulation on the other hand. Prolonged exposures to extreme temperatures may result in the imperfect action of the heat-regulating mechanism with local damage, a burn or frost-

bite, and general disturbances. It is an interesting example of the production of the same or similar effects from the most different agencies, that the local and general effects from a burned and frozen part are from the standpoint of the pathologists very much alike.

Chemical Factors.—Even such obviously necessary exogenous developmental stimuli as food, water, and air may be the cause of or the means of conveyance of disease, as every student of elementary hygiene realizes. Water composes about 70 per cent by weight of our bodies, and we are absolutely dependent upon a constant supply of it for our existence, yet an excess of water under certain circumstances, even when taken in the ordinary way by mouth, may be the source of a definite intoxication or poisoning, as has been shown by Rowntree and others. Conklin gives some interesting examples of the effect of variations in food upon some of the lower animals, effects which are so striking in some cases as to resemble hereditary differences. For example, "if canary birds are fed on sweet red pepper they become red in color. If the larvae of bees are fed on 'royal jelly,' which is a bee food rich in fats, they become fertile females, or queens; if fed on ordinary 'bee bread' they become infertile females or workers. There are marked structural differences between the workers and the queens, but the differences in their habits and instincts are even more striking; all of these differences, whether in bodily structure or in instincts, are determined by the character of the food and not by heredity. Innumerable cases of a similar sort could be named, which show the great effect of environmental stimuli on development, but not upon heredity."

As important ingredients in man's food we recognize (1) the three types of heat- (or energy-) producing foodstuffs, namely, proteins, carbohydrates and fats; (2) certain necessary mineral salts; (3) water; and (4) other intangible but necessary substances that are popularly known as "vitamins." If an otherwise abundant diet be deficient in these last-named substances, certain disease states, the so-

called deficiency diseases (for example, scurvy) may develop. Any ordinary well-balanced diet of meat, bread, white and green vegetables, fruits and dairy products, contains an abundance of the so-called vitamins.

Food and water contaminated with certain harmful germs may be the means of conveying infectious diseases like typhoid fever, dysentery, and cholera.

The abnormal exogenous factors, especially the bacterial poisons, are directly responsible for a large share of human mortality and, in those patients who recover from the acute illness, they are indirectly responsible for various degenerative conditions in different organ systems, which may lessen the general resistance to other harmful agents or lead to changes that may become progressive. It is also generally believed that the relatively minor localized bacterial lesions, the so-called focal infection in the tonsils, at the roots of teeth, in the paranasal sinuses, the gall bladder, the prostate, the Fallopian tubes, etc., may, by the production of toxins or by the sending off of small numbers of bacteria into the blood stream, be an important element in undermining the general health and in setting up inflammatory disturbances in different parts of the body.

The animal parasites, although of less importance than bacteria, also take their toll of human life and health; malarial, amœbic and trypanosomal infections, and infestation with hook worms, tapeworms, flukes, etc., are notable examples. Some medical historians have been inclined, though we believe erroneously, to attribute the decay of the Greek and Roman civilizations to the widespread infection of the inhabitants with malaria. Great progress has been made in combating infectious diseases of both bacterial and animal origin through the increase in knowledge of the causes of such diseases, of the modes of infection, of immunity, and of methods of prevention and treatment. Certain sections of the world, like the Panama Canal Zone, formerly hot-beds of disease, have been made not only

habitable, but as healthful as highly civilized states in the temperate zone.

Of great interest in recent years has been the study of the hypersensitiveness of some individuals to certain foreign protein substances, like the pollen of certain plants, the hair of animals, and even ordinarily wholesome foodstuffs. This hypersensitiveness, which seems in many cases to be an inherited trait, may be productive of bronchial asthma, hay fever, eczema, and certain other diseased states that may lead to degenerative conditions.

Man comes into contact with inorganic poisons in various ways, as, for example, through occupation (lead, arsenic, benzol), by using them as medicines (arsenic, mercury, alcohol, ether, chloroform) or through purely sensual indulgence (alcohol, tobacco). Though many of these substances are of great value when properly used, large amounts are undoubtedly deleterious and it is believed that they may be conducive to the origin of some of the most characteristic of the degenerative diseases, such as arteriosclerosis, cirrhosis of the liver, and certain lesions of the nervous system.

Endogenous Factors.[1]—Our bodies may be likened to vast test tubes in which innumerable physico-chemical reactions are constantly taking place. There is always going on a tearing down and a building up of tissue, a burning up of foodstuffs, an excretion of waste material, etc. These processes in general constitute what is known as "metabolism." The building-up activities are grouped under the term "anabolism," and the tearing-down activities under the term "catabolism." In other words, metabolic processes are divided into two sets, the anabolic and the catabolic. Many of these processes are oxidations, the oxygen being carried to the tissues from the lungs by the red blood corpuscles. Through oxidation, materials are burned up and heat and energy are furnished to the organism. The ultimate products of this combustion are water and carbon

[1] These endogenous factors belong to the subdivision of "internal environment" mentioned in a preceding footnote.

dioxid, both in themselves of great importance to the body. Carbon dioxid is the stimulator of the so-called respiratory center in the medulla oblongata, which is the nerve center that regulates the act of respiration. When the carbon dioxid is in excess there is increased rate and depth of respiration; when it is diminished the respiratory movements are inhibited. This substance also, by means of the weak acid reaction that results from its combination with water, helps to maintain the very delicate acid-base equilibrium of the body fluids, so delicate that a change in the reaction as great as that from tap water to distilled water is incompatible with life.

In addition to the ordinary products of metabolism like carbon dioxid, which as we have seen is so important in regulating the body's activities, there are other substances called "internal secretions," which are formed in certain glandular organs and are given off by them to the blood stream. These are also of great importance as developmental stimuli and as regulators of the metabolic processes. Upon their normal behavior in early life depend the proper growth and development of the child, the occurrence of puberty at the proper time, the development of the secondary sexual characteristics and instincts, the distribution of fat, the nature of the bony framework, the utilization of certain foodstuffs and the proper regulation of many other metabolic occurrences.

When these normal endogenous stimuli are replaced by abnormal ones (perverted secretions and products of abnormal metabolism), health gives way to disease, and among the diseases caused in this way are some that are important factors in the origin of certain degenerative processes. The disease known as "gout" has, as its presenting symptoms, pain, swelling, and disability of one or more joints (arthritis), due to the deposit in the tissues of the joints of salts of uric acid. It is not known just why these deposits occur, but the condition is associated with an increase in the uric acid of the blood and an inability on the part of

the body to take care properly of the so-called purin substances, which are combined with certain protein constituents of the tissues and of the food and are the forerunners of uric acid. It has long been believed that this metabolic abnormality is an inherited trait, but many environmental factors are of importance in precipitating attacks—for example, overeating and especially the eating of animal foods rich in purins (sweetbreads, liver, kidney, sardines), alcoholic intemperance, and lack of exercise. In addition to suffering the excruciating pain of acute attacks and the disability of chronic arthritis, the victim of gout is also prone to a degenerative change in the arteries and kidneys, productive of arteriosclerosis and of Bright's disease.

In diabetes mellitus the body is unable to metabolize the carbohydrate foods properly, owing presumably to a lack of "insulin," the internal secretion of the pancreas. The amount of sugar in the blood is increased (hyperglycæmia) and sugar appears in the urine (glycosuria). In severe cases there are also defects in the processes of metabolism of fats and of proteins. Combustion of the fats is incomplete, toxic decomposition products (oxybutyric acid, diacetic acid, and acetone) are formed and may be demonstrated to exist in the urine and in the blood; the resulting condition (acidosis) is the most serious complication of diabetes. Patients with mild diabetes and even with diabetes of moderate severity may under careful treatment live for many years, but they show a decided tendency to the development of degenerative changes, especially of the arteries and of the nervous system.

Other excellent examples of degenerative conditions dependent upon endogenous factors operating through the glands of internal secretion may be found in disturbances of the thyroid gland, which is situated just below the Adam's Apple in the neck and which when enlarged produces the swelling known as "goiter." The thyroid secretion is very important in early development and exerts a profound influence on metabolic processes throughout life. A lack of

this secretion in childhood is mainly responsible for the cretin, a human being who is physically underdeveloped, with short deformed bones, delayed dentition, etc., and who manifests mental impairment often to the degree of idiocy. A similar condition in adult life is called "myxœdema" or "hypothyroidism" and is associated with a retarded rate of metabolic exchange, obesity, sluggish muscles, dryness and a peculiar swelling of the skin, constipation, mental dullness and apathy. The toxic goiters, exophthalmic goiter and toxic adenomata (the so-called hyperthyroid states) are characterized by an accelerated metabolism, emaciation, an alert, overactive mind and body, rapid pulse, nervousness, tremors, diarrhœa and, in severe cases, extreme prostration. In most cases of thyroid disturbance, the disease is of long duration and shows remissions and exacerbations. Characteristically associated with thyroid disease is a degenerative state of the heart muscle (myocardium), with the production of the so-called "goiter heart."

Psychic and Social Factors.—It is with respect to the influences of psychic and social factors that man's development differs most from that of lower animals. Man's heredity, in principle, is similar to theirs; the physical and chemical stimuli are much the same; but, as we have already pointed out, his environmental influences are rendered vastly more important by reason of his long period of immaturity, during which these forces play upon him, of the greater range of his possibilities, of the great number and variety of environmental stimuli that act upon him, of the development of a higher order of memory and intelligence with the possession of a will to bend his surroundings to suit his desires, and of the highly complex civilization built up by the race and to which he is heir (in the ordinary property use of the term, inheritor). Man's mental endowment is not an unmixed blessing from the standpoint of health and disease. He can undoubtedly avoid many ills by the exercise of his educated intelligence and will, but his highly developed

emotions bring evils in their train, evils that are apparently on the increase.

Men of the present day do not fundamentally differ greatly from those of centuries ago, but their psychic and social environment, their ambitions and their responsibilities, have changed enormously. In the attempt to keep pace with the strenuosity of the times those who succeed do so at the expense of an effort and an unremitting application that result only too often in serious breakdowns at middle age, the period when they should be at the height of their power and influence. There are increasing numbers of men who fail to make the proper adjustment, and who, succumbing to their primitive instincts, fall into habits of crime and of general depravity and swell the population of our insane asylums and our penal institutions.

The nervous system of man and other higher animals may be divided into several different parts. 1. The brain is the seat of the nerve centers of most important activities and of association tracts of nerve fibers between these centers, the combined activities of which are responsible for psychic phenomena. 2. The spinal cord situated within the vertebral canal contains bundles or tracts of nerve fibers running to or from the brain and groups of nerve cells by which are mediated the very valuable reflex mechanisms for rapid response to external stimuli. These two, the brain and the spinal cord, are spoken of as the central nervous system. 3. The peripheral nervous system is also divided into two different portions, the voluntary or medullated nerves and the involuntary, non-medullated nerve fibers. Each of these is further divided into afferent and efferent fibers, respectively passing to and from the central nervous system. The working of the voluntary nerves may be illustrated by the nerve impulses and pathways involved in talking, in walking, in writing, in doing the thousand and one things that are under direct volitional control. The involuntary, autonomic and sympathetic, nerve fibers connect the central nervous system with the inner organs, with their secret-

ing glands, with the muscles, with the muscular walls of blood vessels, with the sweat glands, with the muscles of individual hairs, etc. Over the activities of these structures we have no direct voluntary control. Under the usual conditions of health there is a very delicate adjustment in the autonomic nervous system between those fibers that stimulate or augment secretion or motility and those fibers that inhibit or reduce these activities. For example, the heart muscle is supplied with two sets of fibers, one of which tends to increase the heart rate, the other to slow it. We are quite unconscious ordinarily of the phenomena that are constantly going on under the control of this marvelous mechanism. When derangements occur, very marked symptoms may arise, which bring them acutely into the field of consciousness. Nausea and vomiting, for instance, are due to an abnormality of the involuntary neuro-muscular mechanism of the stomach, which may be initiated in a great variety of ways. It may be due to a local irritation of the stomach; to a reflex action, the irritation arising in an inflamed appendix or gall bladder; to a central nervous lesion such as a brain tumor or meningitis; or again to purely emotional factors operating through the higher nerve centers.

Even in laboratory animals, as Cannon has emphasized, the emotions of pain, hunger, rage, and fear have a very marked effect upon the bodily mechanism, as shown definitely by physiological experiments. In man, with his more highly organized nervous system and especially with his powers of imagination, the emotional factor assumes a much more important rôle in the production of abnormal bodily states than in other animals.

The social factors of environment are intimately connected with the psychic features, especially in the formation of habits, in training, and in education. The social surroundings of luxury and of poverty may each have advantages and disadvantages. In the cultured home of educated parents the child may be given the best possible care during infancy and adolescence, the proper diet, regular

hours of rest and of exercise, and protection from infectious diseases as far as intelligent care can guard against them, whereas the home of poverty may also be the home of neglect, of drudgery, and of disease. On the other hand, what we sometimes call "good environment" may furnish too much luxury, too much ease, too little incentive to work, to accomplishment, and to the overcoming of difficulties since there may be no difficulties to overcome. Hence it is not unusual to encounter there products that are disappointing when measured by high standards of personality and accomplishment, or to meet there with examples of mal-adaptation of sufficient degree to constitute "disease." Some of the world's greatest men have come from humble homes, where in the hard school of necessity they had learned habits of work, of persistence, of thrift, and of endurance. In the one case the latent powers remain latent; in the other they are discovered, exercised, and made strong.

Under the heading of social factors there must be considered also the disease-producing influence of occupation, of the organization of industry with its highly specialized and monotonous tasks, of overcrowded tenements, of bad ventilation, of hunger, of gluttony, of unemployment, and of overwork. Arterial hypertension (high blood pressure), with its attendant and resultant degenerative changes, is found not infrequently among people of nervous temperament who drive themselves at high speed with insufficient rest, no vacations, and no out-of-door recreations to relax the mental tension and to give the body the exercise that is necessary for health.

PART TWO

THE PRINCIPLES OF PREVENTION AND OF POSTPONEMENT OF THE DEGENERATIVE DISEASES

CHAPTER V

EUGENICS

In the prevention or postponement of the degenerative diseases, due, as we have pointed out, to factors both of heredity and of environment, there are two sets of measures to be considered—(1) that based upon the application of the principles of heredity (eugenics) and (2) that based upon the study of environmental agencies (euthenics).

We have endeavored to point out that, in the development of the individual, Nature is more important than Nurture and it must again be emphasized here that Nature, or heredity, is all important for the evolution of the race. In the development of the human being more than in that of any other creature, however, environmental factors play an important rôle. The illustration of the effect of different foods upon the development of bees illustrates the great significance that may be attached even to a single type of environmental stimulus upon lower forms of life; but it must be remembered that there is practically no evidence that traits acquired through environmental influences are ever inherited, and so they are important only for the individual and not for the race.

Human evolution has obviously made great progress since the days of the so-called "Foxhall man" whose fossil remains have been found in England and who is believed to have lived before the Great Ice Age, about 500,000 years ago. Geologists and anthropologists trace a progressive evolution through the "Trinil man," the "Piltdown man," the "Neanderthal man," with his industries and his ceremonial burial of the dead, to the "Cro-Magnon man," who lived about 25,000 years ago and left relics of his prehistoric painting

and sculpture. But within historic times there would seem to have been but little, if any, definite improvement in man's inheritable capacities, although advances in civilization and its increasing complexities enable him to make more of his innate possibilities. It is widely believed that no modern race of men has equaled that of the Athenians in the days of Athens' glory. Their high intellectual qualities were probably due, as Bateson suggests, to the inbreeding of homogeneous and very superior lines, and this superiority declined with the institution of certain political reforms that sanctioned foreign marriages and the admission of aliens and freed slaves to citizenship.

The lack of recent advance in human heredity is in striking contrast to the marked improvement that has occurred in domesticated animals. The discrepancy is due to the fact that for centuries breeders of animals have very carefully selected their stock for mating purposes and have not depended upon environment to improve their breeds, whereas with man just the opposite has obtained. He has believed that good environment would achieve the desired end and through the development of civilization he has not only nullified the natural selective mating of the wild state, but has actually encouraged the propagation of the unfit through democratic regard for personal rights.

With increase of knowledge concerning heredity it was a natural step to consider the possibility of improving the human race by application of the principles of heredity, and Francis Galton, known as the father of modern studies of heredity, is also the father of the doctrine of eugenics, which he defined as follows: "The science of improving stock, which is by no means confined to questions of judicious mating, but which, especially in the case of man, takes cognizance of all influences that tend, in however remote a degree, to give to the more suitable races or strains of blood a better chance of prevailing speedily over the less suitable than they otherwise would have had."

In the commercial breeding of animals and in scientific

experiments upon animal breeding and upon plant cultivation, man makes no attempt to change the laws of nature, but he discovers these laws and guides his activities by his knowledge of them. Darwin taught that in the wild state the natural selection of individuals showing desirable characters gradually led to improvement in these characters and so to the production of new races. It is now held that selection operates chiefly in sorting out different traits in impure lines and then maintaining them, that the traits themselves are not in any way changed. Hens may be bred for their egg-laying capacity and it will be found that several strains may be separated, some strains laying on an average many more eggs than others, but it is not possible to increase the egg production within any strain by further selection. Many of the most striking results of the botanists have been obtained by hybridization—that is, by crossing related lines. In some cases the hybrids are more vigorous and more fertile than the parent lines. By this method new combinations of Mendelian factors are obtained, which may result in the development of new characters.

De Vries propounded the theory that evolution takes place by jumps or "mutations" rather than by the gradual creeping championed by Darwin. According to this view the variations in individual members of a race or line are of two sorts, *fluctuations* due to environmental differences, which are not inherited, and *mutations* due to sudden changes in the germ plasm, which are inherited. Although details of his work have been criticized by several biologists, his doctrine of the importance of "sports" or mutations in evolution has been generally accepted and the study of the origin of mutations has been and is being pursued with vigor.

The many varieties of domesticated animals (for example, of horses, cattle, hogs, chickens, and pigeons) have been produced through long-continued careful artificial selection, with due attention by the breeders to the traits that they desired to emphasize. The results were obtained in some cases by separating out pure lines from mixed strains, in other

cases by hybridization or deliberately mixing strains, and in still other instances by taking advantage of spontaneously occurring mutations. In producing these highly bred stocks the breeders have, of course, rigorously excluded all but the most desirable individuals from mating.

The problem of human eugenics, though similar in some fundamental biological respects to that of improvement of beasts, is in most ways vastly different. There is in the first place no mundane, omniscient superpower to do the selecting. If there were, there is every reason to believe that great improvements could be made in the human race in a few centuries, despite its mongrel nature, slow breeding, and small number of offspring. Society at large, to which the individual is in many ways subordinate and to which all such matters must be delegated, is in a sense a superpower; but society is very far from being omniscient in its knowledge of heredity or in any other respect. Scientific knowledge of human heredity at present warrants no more than a beginning in attempts to control it. There is ample evidence, however, that through our social organization and public-health activities many weaklings that formerly would have perished at an early age are saved; that many of these, though obviously unfit, are permitted and even encouraged to mate and to produce children, to the detriment of the race. Medical science cannot do otherwise than attempt to save all those intrusted to its care; the bad must be rescued with the good. But beginnings are being made in the state control of the marriage of the feeble-minded, the hopelessly insane, the epileptic, the congenitally blind, the deaf and dumb, and those suffering from other inheritable defects that unfit them for useful citizenship. Several states have such laws at present and it is probable that others will follow their example. It is altogether possible that some of this legislation will be too hasty and ill-considered, however well-intentioned it may be, for restrictions should be applied only in regard to inheritable defects, and we have already indi-

cated how difficult it may be to determine in individual cases what is inherited and what is acquired.

Other negative eugenical measures that have been proposed are (1) *segregation* of degenerates, defectives, epileptics, etc., which is generally regarded as impracticable, and (2) *sterilization* of the unfit, which is also difficult from the practical standpoint of detection, of standards, and of liability to abuse. The State of Indiana has a law providing for the sterilization of certain selected inmates of state institutions where there are confirmed criminals, idiots, rapists, and imbeciles. The operative procedure itself (vasectomy) is very simple in the male and does not limit his sexual life. The operation required in the female is more serious, as it involves opening the abdomen. Theoretically, this method of eugenical sterilization is an improvement over that of mere restriction of marriage in that it prevents the probable increase of illegitimate children. But public opinion does not as yet support the enforcement of the law.

There are other factors in civilization that must be considered in discussions of eugenics. *Racial amalgamation* is steadily going on. This is comparable to the hybridization of different strains by breeders and may result in the production either of inferior or of superior races. Immigration is, of course, a large factor in this amalgamation. The importance of immigration from the standpoint of eugenics may be visualized if it be recollected that within a single generation of the many millions of immigrants admitted to the United States some two millions have had an intelligence below the level of that of the average negro!

War is in many ways the greatest evil that can befall mankind, and in no way is its harmful effect more potent than from the standpoint of eugenics. It kills off the young, the vigorous, the capable, and leaves the weak, the incompetent, and those who are otherwise unfit for military service. However beneficial it may be in promoting the development of the individuals who survive it, there can be no doubt of war's evil effect upon the race.

The *birth-control* movement, which advocates general re-

duction in the number of children with the slogan "fewer and better children," merely states in another way the mistaken belief that improved environmental influences will improve the race. If birth control could be limited to those families in which there is undesirable heredity and rigorously refused by those whose heredity is good, it might be an unmixed blessing to mankind. Unfortunately, almost the exact opposite prevails. Social groups that average less than four or five children per family are destined to extinction. Statistics indicate that the birth rate is highest among the inferior hereditary stocks, lowest among the superior stocks.

Is science in a position at present to offer *positive* eugenical advice? Galton suggested a social policy that would delay the age of marriage among the relatively unfit and hasten it among the strong and healthy. He presented statistics that show that marriages at the age of twenty-two would produce at the end of one century four times as many offspring as marriages at the age of thirty-three and at the end of two centuries ten times as many. Siemens in his *Race Hygiene and Heredity* urges social legislation that will equalize the economic burdens of families with several children and of families with few or no children.

Some general interest has been aroused in eugenics by education, as is shown by the legislation already mentioned, but until this education has been greatly extended, opportunities or requests for eugenical advice will be very infrequent. Eugenical considerations enter very little, if at all, into the arrangement of most marriages. Science is in a position to offer very definite advice in regard to a number of inheritable defects; undoubtedly people with really serious hereditary defects should not have children at all, except by the method of adoption. When the inheritable defects are slight, Davenport suggests that they may be disregarded entirely, or weakness in any given desirable character may be mated with strength in that character. Some would extend this method to more serious defects on the ground that, in general, strength in the rudiment of a char-

acter is dominant over weakness, but Conklin points out the danger of this; for, even if the view be correct, the weakness then merely becomes recessive in the offspring and may later reappear if their children mate with others carrying the same recessive rudiment.

Attempts are being made definitely to classify hereditary human traits as dominant or recessive. It is now believed that a number of the rarer medical anomalies are recessive characters, a view that is in accord with the fact that they are particularly prone to appear among the offspring of consanguineous marriages—that is, marriages of closely related persons. As every one knows, a strong sentiment has long existed not only among civilized races, but also among the more primitive, against close intermarriage, and whatever the origin of this sentiment may have been, we now know that it is biologically well founded, since undesirable traits due to the constitution of the germ plasm tend to appear in the offspring of cousin marriages (inmatings), whereas they tend to disappear in the descendants of parents who are not of the same blood (outmatings). Consanguinity is to be dreaded, of course, only when there are hereditary defects in the germ plasm. There is no danger if the stock be untainted. But there are few human stocks that are wholly free from undesirable traits, and the general taboo against such marriages has been a wise one.

There are some degenerative states of the nervous system that appear in the offering of consanguineous marriages when the stock is correspondingly tainted. Among them are hereditary spastic paralysis, congenital deaf-mutism, retinitis pigmentosa, myotonia congenita, imbecility and certain forms of insanity (dementia præcox). Other heredofamilial diseases, like Huntington's chorea, which is dependent upon a hereditary character that is dominant, may be as prevalent among the offspring of outmatings as of inbreedings.

In view of the fact that longevity, as we have already pointed out, is determined largely by heredity, it must be true

that many, or all, of the degenerative states of later life that lead to natural death are also hereditarily determined. Certainly there is a marked familial tendency in some of the most important degenerative diseases; this is especially true of arteriosclerosis. From a purely theoretical standpoint it would seem altogether probable that the average duration of human life would be greatly prolonged if the rigid eugenical methods of animal breeders could be applied to man. But would this be advisable even if it were practicable? We have as yet no assurance that the trait of longevity is necessarily associated with other good and desirable traits, nor could we be sure that much genius would not be eliminated because its inheritance factors did not happen to be chromosomally linked with the factors for longevity. Again, though it is altogether probable that the average duration of life could be prolonged by selection with respect to the trait of longevity, it is altogether improbable that the extreme span of human life could be much, if at all, extended by any combination of eugenical and euthenical measures. As we have already seen, the maximal duration of life is fairly definitely fixed for each species. By rigid selection, only those strains that are characterized by the extreme longevity of from eighty to one hundred years might be permitted to survive and to multiply, but after these strains had been sorted out no amount of selection could be expected to add more years to the life of members of the human species. If, in an individual case, reason should control matrimony and there were a particular desire for longevity of offspring, there is no more promising method than that of choosing as a marital mate one whose progenitors were extremely long lived.

CHAPTER VI

EUTHENICS

By euthenics we mean the application of our knowledge of the influence of environment to man's development, to the promotion of his health, and to the prevention and cure of his diseases.

Though we have no apology to make for the emphasis we have placed upon the importance of heredity for predisposition to disease, on the one hand, and for longevity on the other, nor for the stress we have laid upon eugenical measures in order that the human race may be fundamentally improved, we have no desire to belittle in any way the importance of euthenical measures, the study and application of which have resulted in tremendous gains to human beings, especially during the past few decades. Eugenics is an innovation founded upon a very youthful branch of science (the study of heredity); and, though data bearing upon the importance of applications of its principles are being accumulated, as a practical force in civilization it has, as yet, hardly been felt. Men have, on the other hand, been thinking in terms of euthenics for thousands of years. The results of their studies have varied, of course, with the extent of their knowledge and education, but especially during the past century the progress of hygiene and of sanitation has been so rapid that the subject of preventive medicine by means of euthenical measures has become a complex specialty embracing many subdivisions, including bacteriology, the sciences dealing with infection and immunity, protozoölogy, medical entomology, sanitary engineering (with its subdivisions of sewage disposal, water supplies, etc.), vital statistics or biometry, quarantine, industrial

hygiene, school hygiene, personal hygiene, and still other subjects.

During the latter half of the nineteenth century the attention of scientific medicine was focused sharply upon the extracorporeal sources of disease and the dramatic development of bacteriology, and of our knowledge of infection and immunity, gave an extraordinary impetus to the study of hygiene and sanitation and to their practical application upon a large scale.

Changes in the Expectation of Life.—The gradual improvement in euthenics from century to century and its very rapid progress in the past hundred years have produced tangible results, as may be shown by a comparison of the life tables available from former times with those of to-day. Such tables have been compiled from mortality statistics in the city of Breslau in the seventeenth century and from the very interesting though less reliable records of Egyptian mummies of about 2,000 years ago and of the citizens of Rome at a somewhat later date. Comparison of the life curves at these different epochs shows that the average expectation of life at birth has progressively increased. The oldest figures did not concern early life with sufficient accuracy to justify numerical comparisons. But the increase in the expectation of life of an individual born in the United States in 1910 over that of one born in Breslau in the seventeenth century was approximately eighteen years. At ten years of age the modern American has an average expectation of life twelve years in excess of the seventeenth-century child; at twenty years of age the increased expectation is a little less than ten years, and at fifty it is some four years greater than that of his mediæval counterpart. Comparing the figures of the eighteenth century with those of the present, we find a similar trend, but less in degree; and on comparing the figures derived from the ancient records of Egypt and of Rome it is found that the trend is still quite similar, but of greater degree. In all the comparisons, the differences in expectation are much greater for the early

ages of life; for middle age the expectation of life was substantially the same in the eighteenth century as it is now, and it was not greatly different in the seventeenth century or in earlier times. It is, further, very interesting that for the more advanced ages the curves show a greater average expectation of life for the Egyptians, the Romans, and the seventeenth-century inhabitants of Breslau than for those living at present. There was in earlier times a tremendous mortality in infancy and in youth, and somewhat lower mortality in middle age. Only the very strongest people survived to three-score years and ten, and their unusually sound constitutions were probably stronger than the average of those living at that age to-day. Pearson states it thus: "Out of one hundred English alive at ten years of age, thirty-nine survive to be sixty-eight; out of one hundred Romano-Egyptians not nine survived. Looking at these two curves, we realize at a glance either the great physical progress of man, which enables him far more effectually to withstand a hostile environment, or the great social and sanitary progress he has made, which enables him to modify the environment. In either case we can definitely assert that 2,000 years has made him a much "fitter" being. In this comparison it must be remembered that we are not placing a civilized race against a barbaric tribe, but comparing a modern civilization with one of the highest types of ancient civilization."

There is now general unanimity of opinion that this change has come about not through any inherent improvement in man's physical strength, but through a great increase in his scientific knowledge and its application in hygiene, in public health and social activities. The knowledge of bacterial causes of disease and of the methods of transmission of these diseases has given man a powerful weapon against them, and much of the improvement in the health of the public has resulted from the partial or, in some cases, complete conquest of these important enemies. It may be justly emphasized here that this great boon to humanity has been due in large measure to the results of animal experimenta-

tion, and that even the most fanatical antivivisectionist is daily profiting by the knowledge so gained.

Community Hygiene.—Social regulation of hygiene in some form goes far back in history and is to be observed most prominently in the history of the ancient Hebrews. The priests served as medical police, and not only were there a great many sensible rules with regard to the segregation of the sick, the disinfection of "unclean" articles, proper diet, hygiene of menstruation, the abomination of sexual perversions, etc., but these rules were vigorously enforced until they became an intimate part of the Jewish civilization, which persisted even after the Jews were scattered over many lands. Their comparative immunity to epidemic diseases during the middle ages was the object of wonder, of envy, and often of suspicion among their Christian neighbors. The beginnings of modern governmental regulation of public hygiene were made in times of great distress because of the enormous losses of life in pandemics of infectious diseases like Asiatic cholera (1826–37, 1840–50, 1852–60, 1863–70), cerebrospinal fever (1805–30, 1837–50, 1854–74), influenza (1830–33, 1836–37, 1847–48, 1889–90, 1917–20), yellow fever, typhus fever, and bubonic plague. The extension of public-health legislation, at first gradual, has been more rapid in recent years. It has always been opposed by business interests that were believed to be threatened and by political opposition to paternalism in government. The municipal, state, and national regulations, designed to safeguard health, now accepted as wise and provident by the majority of citizens, were once assailed as vigorously as are those now pending in legislative halls. A classical early example of the protest of "business interests" or of the "champions of individual liberty" is to be seen in the riot of the Parisian rag-pickers during the cholera epidemic of 1832; they resented the removal from the streets of the piles of waste materials from which they derived their livelihood.

Many of the requirements of modern hygiene are entirely

beyond the scope of the individual and must be put into force by the society at large. The general health of any community can usually be fairly well estimated by the authority and the capacity of its department of health. A great many practical points of hygiene, however, still remain in the hands of the individual, and the benefits that he may derive from scientific teachings depend upon his intelligence, upon his education, and especially upon his interest in applying them to himself and to those for whom he may be responsible.

We have quoted in an earlier chapter the opinion of biologists that the time at which natural death occurs is determined by the inherent physico-chemical constitution modified by the impact of environmental forces that act chiefly in the direction of determining the rate at which the inherited endowment is used up. We have indicated also the vast number and variety of environmental forces that aid in bringing about man's development (the evolution of the person) and which have a bearing upon the onset of his involution and upon the origin of the degenerative changes that lead to death. Fortunately, man's use of his environment is in large measure instinctive, and a person of sound constitution may develop, remain well, and thrive with little or no special education in hygiene. This statement should perhaps be restricted to man in his natural state, for with the ever-increasing complexities of modern civilization man is now living in a way far divergent from that of his "natural" condition. With the introduction of closed houses, which helped him to become independent of weather conditions, man's possibilities were increased but new hygienic problems were added. The same is true of the introduction of thick garments; of changes in the methods of food preparation; of the crowding incident to life in large towns and cities; of the invention of new methods of transportation, heating, and lighting. Many of the hostile environmental forces have quite properly come to be under community control; thus sewage disposal, the purification of

water supplies, milk and dairy inspection, the quarantine of infectious diseases, the compilation of vital statistics, the regulation of child labor, as well as compulsory education, are now matters that are dealt with by collectivity rather than by single persons.

Personal Hygiene.—There still remains, however, a vast field covered by the term "personal hygiene," in which the responsibility rests upon the individual alone, or upon his guardians during the important stage of his immaturity.

Protection of the Germ Plasm.—The consideration of personal hygiene begins properly with the hygiene of parents, the guardians of the precious germ plasm, which, as we have noted, may be damaged to some extent by unhygienic conditions, as for example, by syphilitic infection, by alcoholic intoxication, by mineral and organic poisons, or by extreme malnutrition.

Prenatal Care.—The second phase concerns prenatal care, due attention to which has saved many lives of mothers as well as of infants. One of the cardinal points in prenatal care is that prospective mothers should place themselves early under the supervision of competent physicians, either family doctors or obstetricians, or should register at a clinic for prenatal care. The prospective mother should be instructed as to proper diet. She should be told that there is no more need than there is desire to eat for two, especially during the first four months of pregnancy; that a general well-balanced diet, though with relatively little meat, is best; that a sufficient intake of fluids (at least three quarts daily) is important; that, fortunately, the embryo appropriates what it needs from the mother's blood and is thus, to a certain extent, independent of the mother's appetite or caprices. She should be taught further to make use of loose clothing, to pay special attention to the excretory organs, and, in general, to keep as fit as is possible by means of daily baths, daily exercise, and suitable diversion. She should, through the doctor's reassurance, be relieved with regard to the many superstitions and bugaboos that are particularly associated with

pregnancy, especially with regard to the widespread fear of "maternal impressions" and of the "marking" of the child. The greatest benefit of professional attention comes to those in whom there is danger from some of the serious complications of pregnancy; when these complications are prevented or are discovered in time, the lives of both mother and child may be saved when but for such care they might be lost.

Hygiene of Infancy and Childhood.—At birth, the child first comes into contact with the environmental factors of the world outside the mother—with food, water, temperature changes, and increased danger of infection. For many years the child is quite incapable of steering his own course and is entirely dependent upon the devotion, the intelligence, the patience, and the willingness for self-sacrifice of his parents in order that they may care for his daily needs, may teach him the spirit of accomplishment, develop his ability to bear disappointments, and train him in the art of living.

During the first year or two the welfare of the physical side of the child is of paramount importance; suitable provision must be made for nourishment, housing, clothing, rest, and sleep at regular hours, and protection from infection and from injury. The propaganda of obstetricians and pediatricians for the breast-feeding of babies has had a widespread and beneficient influence; many infant lives have been saved and the babies started on the right road to physical health through a diet of mother's milk continued for the proper period. It is well to remember the importance of proper habits even for children of tender age, for an infant readily forms habits. More people nowadays than formerly realize that a baby is not a plaything, but represents a serious responsibility; it requires regular and sufficient nourishment, rest, sleep, and protection. The growing custom of having each child under a physician's observation at regular intervals, whether it be well or ill, is to be highly commended. In addition to advice as to diet and habits, the physician can keep the parents informed of the possibilities of the prevention of infectious diseases and see to it that the child reaps

the benefits of our knowledge of prophylaxis. The best known example, of course, of prophylactic intervention is vaccination against smallpox. There is also available now an effective method of immunization against diphtheria. By means of the Schick test (the injection of a minute dose of diphtheria toxin into the skin) it is possible to determine whether or not a child is susceptible to diphtheria. If the child be found to be susceptible a small amount of a mixture of toxin and antitoxin can then be administered subcutaneously for several doses, which, though causing practically no unpleasant reaction, confer, in a majority of cases, lasting immunity to the disease. Parents are now beginning to understand that the more common acute infections of childhood, as, for example, chicken pox, whooping cough, measles, and mumps, are not necessary and inevitable or even relatively harmless. They are learning that they are the causes of an enormous mortality and that even in many non-fatal cases the child's resistance to tuberculosis and to other diseases similarly dreaded may be markedly reduced. Consequently the old attitude of permitting or courting exposure with the idea of "getting it over now" is giving way to the new attitude of more careful protection from exposure, more conscientious quarantine, and a desire for specific prophylactic measures.

Most parents are not fully awake to the importance of the psychic and social sides of the child's development and of their relationship to the possible occurrence of psychoneurotic symptoms in later years (especially if the child be predisposed to nervousness). Psychic and social influences are highly significant for the formation of ideals and for the development of character. Training in this direction should begin very early, as we have already intimated, in the formation of proper habits during infancy. In the later years of childhood, the boy or girl receives impressions from the parents, from other members of the household (including servants), from the neighboring children, from the school, from the church, from books, and from places of entertain-

ment, but the home is the chief place for the cultivation of adequate personal expression, for education to the proper control of the impulses and for favoring the growth of the higher sentiments and ideals. The habits, the interests, and the ideals of the child are gradually developed in the healthful atmosphere provided by a normal family. With respect to training in habits, it may be mentioned, for instance, that parents should know what diet is good for the child, should place the food before him, and should then see that he eats it. If parents are capricious about food themselves, their bad example may be very harmful to the child and may lay the foundation for defective nutrition in later life. Good teamwork on the part of father and mother, consistency with respect to policy and attitude, and a continuous example of cheerfulness and of good will toward others create in the home an atmosphere that is of the greatest benefit to the growing child, for it goes far toward preventing the dangers of that unfavorable "psychic contagion" that is not infrequently responsible for much that has been attributed to heredity.

A discussion of the formal education of the child and of the young adult is beyond the scope of this book.

Some of the environmental factors that are most important alike for the health of the infant, the child and the adult, may now be taken up separately.

CHAPTER VII

AIR AS A FACTOR IN EUTHENICS

Fresh air is tonic and invigorating; vitiated air is depressing and enervating. The harmful effects of a vitiated atmosphere upon human beings may be divided into two general groups, the acute and the chronic. Among the acute effects are lassitude, headache, vertigo, nausea, collapse, and, in extreme cases, even death. The tragedy of the "Black Hole of Calcutta" may serve as an example of the most extreme type. In this military prison 146 adults were shut into a room only eighteen feet square and with two small windows on one side for ventilation. After ten hours only twenty-three of the prisoners remained alive. Much more important from the hygienic standpoint are the more common effects of chronic exposure to contaminated air upon the human constitution. Among them we may mention anæmia, depressed vitality, digestive disturbances, nutritional disturbances, and lowered resistance to infection, with the ordinary pyogenic, or pus-forming bacteria, the tubercle bacillus, the pneumococcus, and the various organisms that are responsible for the ordinary respiratory infections that are so common in winter. Usually when bad ventilation exists there are other unfavorable influences also at work, so that it is difficult to evaluate precisely the harmfulness of any one of them. Considerable evidence has been adduced, however, to show that badly ventilated quarters have a distinctly deleterious effect upon both man and lower animals.

The atmosphere is essentially a mixture of gases and contains oxygen 20.94 per cent (of volume at O° C and at 760 mm. pressure), nitrogen 78.09 per cent, carbon dioxid

0.03 per cent, argon 0.94 per cent, traces of other gases, and in addition dust, water vapor, and other elements. Oxygen is the constituent of the air that sustains all life. Nitrogen, in as far as it concerns man's respiration, is simply a diluent. Argon is inert. Carbon dioxid is a very important portion of the air; it is taken up by plants, which build it up into carbohydrates; it is given off from the lungs of animals. Water vapor is also an important constituent of air, and even dust (in the normal small amount) has several useful functions, one of which is its physical influence upon water vapor in the formation of clouds and in the precipitation of rain.

Rosenau gives the difference in composition between inspired and expired air as follows:

	Oxygen	Nitrogen	Carbon dioxid
Inspired air	20.81	79.15	0.03
Expired air	16.03	79.55	4.38

The expired air is warmer, is greater in volume, and contains more moisture but fewer particles (dust and bacteria) than the inspired air. Under normal conditions of quiet respiration the expired air contains no bacteria; but on talking, coughing, and sneezing many bacteria may be thrown out on tiny droplets of moisture and, if these are pathogenic (disease-producing) germs, they are particularly dangerous by reason of the fact that they have been living under conditions most favorable for their existence and growth and have not been subjected to drying or other harmful agencies.

The amount of carbon dioxid in the air of a room has been, and still is, used as an index of the degree of vitiation of the atmosphere, although it is generally recognized that it is not *per se* the cause of the harmful effects, or of unpleasant symptoms. Various hypotheses concerning the harmful ingredients of "bad air" have been proposed at different times. It was early considered that the deleterious effects were due to the lack of oxygen and to the increase in carbon dioxid; but we now know that this view is not

correct. Others have suggested that poisonous substances are given off in the breath; but the experiments supporting this have, in recent years, not been confirmed, and the general consensus of opinion is against this assumption, although, admittedly, the question is still open. At the present time sanitarians are inclined to believe that the unpleasant and harmful effects of vitiated atmosphere are due to physical rather than chemical causes, especially to conditions of the temperature, the moisture, and motion of the air. Certainly, in experiments of short duration, these factors have been of paramount importance.

Mention has already been made of the wonderfully effective heat regulatory mechanism of our bodies. An excess of heat is lost in two ways: (1) by transfer of heat by radiation, conduction, and convexion, and (2) by evaporation of the water of perspiration. Increase in the temperature of the surrounding air diminishes the amount of heat lost by the first method, and increase in the humidity decreases the loss of heat by evaporation. If, in addition to being warm and humid, the air be still, that portion of the atmosphere in contact with the skin surface is not rapidly changed and all the physical conditions are present that tend to diminish heat loss from the body and to cause physical discomfort. Hence one may realize the value of any agency that causes movement of the air. Gentle draughts are most valuable adjuncts in ventilation; even a small fan is helpful. By increasing the conductivity of the air for heat, humidity has a cooling influence; hence cold, moist air is chilling. By interfering with the evaporation of perspiration, more important at higher temperatures, it has a heating effect; hence warm, moist air is enervating. There is a neutral temperature zone, about 68° F., at which humidity has comparatively little effect. Chilliness may be felt in the warm, dry air of overheated houses, owing to excessive evaporation, and such an atmosphere, the prevailing one in our homes and offices in winter, favors irritation and infection of the respiratory mucous membranes.

In spite of the recognized importance of the purely physical factors of temperature, humidity, and motion of the air, conservative sanitarians are unwilling to exclude other possible harmful influences in vitiated atmosphere and insist that good ventilation necessitates some admixture of outside "fresh" air. Fortunately for us, some air comes in through the little cracks around windows and doors and even through the masonry of the walls, though papering and painting of the inside walls greatly lessen this means of air exchange. There are elaborate methods of ventilating large buildings, which are quite satisfactory when properly installed and operated; but in most houses and workrooms dependence is placed upon "natural" ventilation through windows and doors. For efficient ventilation there should be openings in opposite sides of a room, and this is often difficult to secure without draughts, which cause most people discomfort. There are many simple devices that may be used in windows to deflect the air upward, or which may be placed at the top of windows to facilitate the exit of vitiated air.

Life in the country and the "back to the farm" movement are distinctly unpopular in America to-day. More and more people are crowding into the cities, where the method of living, especially in winter, involves the spending of the largest part of their hours awake in poorly ventilated quarters. Fortunately, the crusade against tuberculosis has taught many people the value of fresh air. The insurance of a satisfactory night supply by the use of sleeping porches, window tents, or even by widely open bedroom windows does much to counteract the lack of satisfactory ventilation during the day. In the daytime windows should be kept widely open in summer and partly open in winter, except in bitterly cold weather. A good deal may be accomplished in winter by watching the house thermometer and making sure that the thermometer remains close to 68° F. or slightly lower. Unfortunately, there is no simple satisfactory and practicable method of securing a proper amount of atmospheric moisture in houses heated directly by steam or hot-

water radiators. A fairly simple and partially effective method is to open the house as widely as possible several times during the day for fifteen or twenty minutes at a time to ensure a thorough change of air. As a rule, times for such a procedure can be found in most households without inconvenience, and the better health resulting will more than compensate for what is lost through the increase of the coal bill. Heating and lighting methods have distinct bearings upon ventilation. Even a small fire in an open fireplace is a valuable adjunct to the ventilation of a room by furnishing a passage for rapid egress of the air and the creation of gentle currents in the atmosphere of the room. Electric lighting is to be preferred to gas or to oil lamps.

Air may be contaminated by poisonous gases (for example by escaping illuminating gas), by excessive amounts of dust and smoke, and by germs. Many lamentable and even fatal accidents have resulted from a failure to pay attention to the ventilation of a small garage before starting an automobile on a cold day.

Dust and smoke are themselves injurious, as is shown by the morbidity and mortality records of some of the dusty trades; and, furthermore, dust particles provide the means of transportation for bacteria in the atmosphere. The old-time broom and duster filled the air of a house with dust and germs. The carpet sweeper was an improvement. But the still more modern vacuum cleaner is distinctly advantageous from the hygienic point of view, and its use and that of moist cloths are more efficient for cleaning purposes.

Direct sunlight and even diffuse daylight are valuable germicidal agents. Most of the bacteria inhaled into our respiratory passages reach them in the form of dust, and are fortunately the less dangerous because they have been thoroughly dried and have been exposed to light. Some bacteria withstand drying and exposure to light for many hours or for days; others for only very short periods of time. But in either event the dry, dust-riding bacteria are much less dangerous than the moist, fresh, warm, active germs that are

sprayed into the air by sneezing and coughing, or by some persons during guttural or sibilant speech. Children should be taught very early to cover the mouth and nose with a handkerchief before coughing or sneezing, not only for the sake of politeness and through consideration of the feelings of others, but also for the very important hygienic reason just mentioned. There are surprisingly large numbers of apparently well-bred people who neglect this simple precaution and thus help to spread respiratory infections in the home, in public conveyances, in churches, in theaters, and in other public places.

CHAPTER VIII

FOOD AS A FACTOR IN EUTHENICS

Food.—Next to air and water, food, the fuel for the human machine, is the most important factor in our environment. It furnishes heat and other forms of energy, as well as materials for the reconstruction of the tissues. Many of our customs relating to food are instinctive, as they are with animals; and most of the customs that are rooted in instinct are beneficial. Some customs, however, are merely fads; and others, such as the bolting of concentrated diets, are due to the stress and hurry of modern civilization. Habit plays a large part in the determination of food preferences, in the choice of meal hours, and in the amounts of foods eaten. We have already pointed out the importance of teaching the child to eat a general, well-balanced diet and to learn to like good foods of many different kinds, for if the diet be satisfactorily varied and be sufficient in amount, all the nutritional needs of our bodies will be met.

The proteins of the food are the tissue builders; they are absolutely necessary for life and for growth. They are very complex chemical substances consisting of various combinations of many different amino-acids, all of which contain nitrogen as an essential element. Many different amino-acids (some eighteen in number) should be included in the diet; hence one's proteins should be derived from a number of different sources in order to insure a sufficient variety in amino-acid content. Possible sources of protein are meat, fish, fowl, eggs, milk, vegetables, fruits, and nuts.

The proteins, besides being tissue builders, are also sources of heat and energy, for they, like carbohydrates and fats, are burned in the body with the liberation of heat. The carbo-

hydrates and fats themselves are completely consumed in the "body-fires" with the formation of carbon dioxid and water, both of which have important rôles to play in metabolism. Excess of carbon dioxid is given off by the lungs; water in excess is excreted through several different channels, including the kidneys, the lungs, the skin, and the intestinal tract. Protein is less thoroughly consumed; it leaves an "ash" or nitrogenous residue that is changed in the liver into urea chiefly, and this urea is then excreted in large part by the kidneys. Among other nitrogen-containing waste products we may mention uric acid, creatinin, and ammonia, which are formed and excreted in smaller amounts.

Carbohydrates and fats are exclusively heat- or energy-producing foods. Among the commoner fats of the food are butter, cream, fat meats, oleomargarine, and vegetable oils (olive oil, cottonseed oil). Among digestible carbohydrates, the sugars and starches derived chiefly from cereals, vegetables, and fruits are the more important. The cellulose of vegetables and fruits is not digestible by man, but it serves a very useful function (as "roughage") in the regulation of the activity of the intestinal tract.

In addition to proteins, carbohydrates, and fats, certain other substances, namely mineral salts and vitamins, are necessary as constituents of a suitable dietary. These are, however, all present in a properly mixed diet of meat, eggs, vegetables, fruits, and dairy products. The mineral or inorganic elements of importance in the chemistry of the body are calcium, magnesium, sodium, potassium, iron, chlorin, iodin, phosphorus, and sulphur.

Vitamins are substances of unknown chemical nature, the presence of which can be recognized only by their biological effects. Undoubtedly several different vitamins are necessary for health, but there is some dispute as to the precise number. One, which is soluble in fat as well as in water, is called "fat-soluble A"; another is spoken of as "water-soluble B." Some authorities believe that a third vitamin,

present in raw milk, in orange juice and in other anti-scorbutic foods, differs from either the fat-soluble A or the water-soluble B. It is believed by some investigators that these substances known as vitamins are injured if not wholly destroyed by ordinary cooking (except in the case of acid fruits and acid vegetables); hence the inclusion in the diet of raw or uncooked articles like celery, lettuce, tomatoes, fruits, nuts, and milk would seem to be advisable.

The nutritive value of the heat-producing foods (proteins, carbohydrates, and fats) is reckoned in heat units or calories. The potentiality of different foods for the production of heat varies a great deal; some foods are very concentrated, containing relatively many heat units; others, though bulky, produce but relatively little heat or energy when burned. A small "pat" or individual service of butter, which is a very concentrated food, has about the same caloric value as has a glass of milk, a very large orange, or two apples of ordinary size. A man of ordinary sedentary habits requires a food-intake that corresponds to about 2,500 calories per day. A man engaged in hard labor needs much more food, say an amount that corresponds to from 3,500 to 5,000 calories daily. Some of us eat too much, others of us eat too little. Most people consume too much protein food, the type of food that leaves a larger amount of residue to be dealt with by the liver and the kidneys. Protein food, furthermore, is stimulating to metabolism in general and is thought by many to excite when taken in excess the organs of circulation. Conservative estimates place the proper proportion of protein at about 10 per cent of the total caloric value of the diet, allowing 30 per cent of the calories as fat and 60 per cent of the calories as carbohydrate. A healthy person need not, of course, weigh his food or compute with precision the number of calories in his diet in order to determine whether or not he is eating a proper amount. His best guides are his appetite and his weight. Under "natural" conditions the appetite is a safer guide than it is in most modern cities, where, owing to the high development of the

culinary art, many people eat more than they need, but where, on the other hand, certain persons, owing to lack of exercise, sunlight and fresh air, suffer from lack of appetite and as a result eat too little food.

Life-insurance companies long ago discovered that the weight of a man has a very definite bearing upon the risk that they assume when they insure his life. In general, they agree that the risks are more favorable among those who are a little overweight up to the age of thirty-five or forty and those who are a little under the average weight when beyond these ages. A thin young person and a fat older person are, in general, poorer risks.

A number of methods have been devised for calculating a person's ideal weight. Most of the simpler ones are based upon the average conformity of weight with height. A convenient scheme is that of Dr. Clyde Guthrie. He allows 110 pounds for 5 feet, and for each additional inch in height adds 5½ pounds in weight. Thus a person 5 feet 10 inches tall should weight $110 + (10 \times 5\frac{1}{2}) = 165$ pounds. There can be, of course, no fixed and absolute weight that must be considered the normal for a person of a given height. The weight may vary with the age, with the sex, with the type of bony framework, and with other factors, so that ten pounds either above or below the calculated ideal need not be abnormal; within this range of twenty pounds the weight should be thought of as being within normal limits. A weight of fifteen or twenty pounds below the calculated ideal in youth and especially a weight of fifteen or twenty pounds above the ideal in middle or later life suggests the advisability of remedial measures to correct the error of nutrition.

Undoubtedly the physical build, or habitus, is often determined by the hereditary portion of the constitution, but it is not infrequently due to the purely environmental factors of overindulgence in food and lack of proper exercise. In those cases in which the tendency to obesity or to emaciation has been inherited, the nutritional abnormality may be com-

bated partly by dietetic and hygienic efforts, partly by other means at the disposal of the physician after careful study of the case to ascertain the reason of the nutritional defect.

From the standpoint of the degenerative diseases the most important dietary errors are those of excess—the ingestion of too much protein or overindulgence in food of all sorts. Obesity, by reason of the increased weight which must be borne, is particularly disadvantageous to those who suffer from any defect of the locomotor apparatus; to those who suffer circulatory disturbances it is harmful by reason of the extra load upon the heart and the increased amount of tissue to be nourished; and to those who suffer from diseases of the excretory organs (especially the kidneys), because of the increased amount of tissue to be served and of the handicap put upon the circulation. Furthermore, Joslin's statistics show that obese persons are far more prone to the development of diabetes mellitus (another and more serious nutritional disease) than are thin people or those of normal weight.

When more food is eaten than is necessary for the growth and repair of the tissues and for the production of the heat and energy required by the body, there occurs an increased deposit of fat in the subcutaneous tissues, in the omentum and mesentery within the abdominal cavity, in the pericardium or membrane covering the heart, and even within certain organs, especially the heart and the liver. The fat may even extend into the walls of the heart between the muscle bundles, and by its mechanical interference with the heart's action add a deleterious influence to other harmful factors such as the mechanical displacement of the heart by the large amount of fat in the abdomen, the increased capillary area to be filled with blood and the extra weight to be borne. When the obesity is non-constitutional in origin, its development is due simply to the ingestion of too much food and the expenditure of too little energy in muscular exercise. The remedy is obvious; the patient should eat less food and should take more exercise. If the obesity be very marked it

is wiser to reduce the weight systematically under the observation of a physician than to try to be one's own doctor. Success does not depend upon resort to fads in diet or exercise. If one simply ingests fewer calories and exercises more, so as to lose regularly on the average one half or one pound a week until the weight is normal, he will be reducing in the right way. By choosing the bulkier articles of food that are poor in calories, one may have the satisfaction of appeasing the appetite and at the same time guarding against constipation or a deficiency in vitamins or mineral salts. In using this method, the concentrated foods, that are rich in calories, especially fats and sweets, should be largely eliminated from the diet; the easily digested starchy foods (cereals, potatoes, macaroni, bread) should be reduced in amount, and the chief dependence should be upon fruits, green vegetables, and a moderate amount of eggs, fish, fowl, and other animal proteins.

In selecting the type of exercise to be taken when reducing weight, one should avoid too sudden a transition from a sedentary life to strenuous physical endeavor. When the obesity is based upon a fundamental constitutional disorder, a very strict dietetic and hygienic regimen under professional direction may be necessary before success can be expected. Thyroid extract should never be taken to cause reduction of weight except when it is prescribed by a physician who has made a careful study of the person.

When more interest is taken in the constitutional factors in disease and when more knowledge has been gained in this important field, physicians will be able to offer still better prophylactic advice to individuals with respect to diet. Even now special diets may wisely be recommended to members of certain families. For example, when there is a definite predisposition to obesity and to diabetes mellitus in a family, the children may well be taught to eat very little sugar, candy, and sweet desserts, and to partake sparingly of the easily digestible starchy foods; in other words, members of such a family will do well to form the habit of adhering to

an anti-obesity diet, one which will tend to counteract the tendency to obesity and will at the same time put the least possible strain upon the mechanism that takes care of the carbohydrates—that is to say, upon the mechanism that is at fault in diabetes. Similarly, for members of gouty families, prime subjects for degenerative disease, the diet should contain no sweetbreads, kidney stew, brains, or liver, and relatively little meat of any kind, for these foods are rich in purin substances.

Errors of deficiency in diet are many and varied. Starvation, of course, results from the lack of sufficient food for the maintenance of the body, but it is surprising how long a person may live without food if water be furnished in abundance. There are certain definite maladies known as "deficiency diseases," notably scurvy and beri beri, which are due to the absence from the diet of substances that were at first called vitamins. There is a strong probability that pellagra also is a disease of this type and that still other less definite nutritional disturbances that lead to ill health may fall in the same category. The fault in the diet in these conditions lies less in a lack of the amount of food ingested than in the failure to ingest a properly balanced ration. In view of the fact that beri beri and pellagra are exquisite examples of degenerative diseases from the standpoint of pathology, it would seem possible that somewhat similar errors of the balance of diet may be at least in part responsible for some of the commoner degenerative conditions of later life. The hygienic lessons to be derived from our knowledge of these deficiency diseases are (1) that the diet in health should contain all the well-recognized types of good food, and (2) that each child should be trained in the habit of eating a varied diet unless there be some definite anomaly or disease of metabolism contraindicating it.

Now a "varied" diet includes raw, uncooked foods, which possess certain special nutritive and health-giving properties. But raw foods may be associated with certain definite dangers of their own, because of their possible contamina-

tion by harmful micro-organisms. Potentially the raw foods that are most dangerous in this respect are those that are most nourishing, for they serve as favorable culture media for bacteria. Milk is a good example. In view of the danger mentioned, the sale of milk is now regulated by public-health restrictions; most of it that is sold in cities has been pasteurized. It is a wise precaution to wash thoroughly all solid foods that are to be eaten raw, although the danger of infection from such raw foods as fruit, celery, lettuce, and tomatoes is comparatively slight.

A lack of certain inorganic elements in the diet may lead to special difficulties. Fortunately, almost all the necessary inorganic elements are contained in an average varied diet. An interesting exception, perhaps, is iodin, the chief source of which is from salt-water fish, clams, oysters, and lobsters. In communities remote from the seacoast, the diet may be so deficient in iodin that the thyroid gland, which utilizes iodin for its work, cannot perform its functions properly and pathological changes are inaugurated, which may later lead to serious degenerative disease in other organs. In all probability, the cause of goiter is much more complex than a mere insufficiency of iodin; but experimental work and clinical observation indicate that lack of iodin is important in the origin of at least certain forms of goiter. Marine and his co-workers conducted experiments on a large scale in which they administered small doses of iodin in the form of sodium iodid twice a year to the school children of Cleveland, with the result that the incidence of goiter among these children was very much diminished. As a result of these demonstrations the city water in some localities is now treated with small amounts of iodin. Another simple method of making up a deficiency of iodin is to add a very little sodium or potassium iodid to the salt used in the kitchen or on the family table.

How one eats is only less important than *what* one eats. And how one eats may, to some extent, determine what one eats. The man who eats in a great hurry, bolting his food

as the carnivorous animals do, is likely to choose the same kinds of food that they choose. This tendency is reflected in the menus of hotels and restaurants and in the habits of eating over most of the civilized world to-day. Most of us do not consider a meal complete unless it include meat of some kind—usually a large portion. Too frequently the harder foods and the leafy green vegetables that necessitate chewing are omitted. It is said that native uncivilized races of men have strong beautiful teeth, but when they adopt the food of civilized men they also begin to suffer from dental maladies.

There are many advantages in eating slowly and in chewing thoroughly. The taste of food is thus better appreciated, the salivary glands are more strongly stimulated, the food is better mixed with the salivary secretion, and a satisfactory first stage of digestion is more certainly assured. When food is eaten slowly, the gastric glands are properly stimulated and, moreover, the food before entering the stomach is reduced to the consistency most favorable for ready admixture with the gastric and intestinal digestive juices. A rapid eater is prone to make use of more salt, pepper, and other condiments than is wise. Though most condiments are irritating to the stomach only, the injudicious use of salt may bring about irritation of the kidneys which excrete the excess; too much salt in the food is particularly dangerous to those who suffer from any disease of these organs. The habit of dusting with salt most foods at the table, even before tasting their flavor, is particularly to be disparaged.

An important hygienic requirement and one that is frequently neglected is the drinking of an adequate amount of ordinary water. Water constitutes about two thirds (by weight) of our bodies. The chemical activities of the tissues are dependent upon its presence; the blood itself consists largely of water; and the excretions, especially those of the kidneys and skin, and to a much less extent those of the intestines, are contingent upon a fluid medium. When the tissues demand water, a sensation of thirst is experienced

and practically compels the drinking of some liquid. This is strikingly noticeable after copious sweating as well as in the disease known as diabetes insipidus, in which enormous quantities of very dilute urine are passed. It is not uncommon for a sufferer from the disease just mentioned to drink ten or twelve quarts of water a day—and even to drink a pitcherful of water at one time!

Though thirst usually leads us to swallow enough water to serve as a medium for the chemical processes that go on in the tissues, still it does not always entice us to swallow enough to secure the best possible results in the way of excretion of waste products. When too little fluid is taken by mouth, the fluids from the intestines may be absorbed into the blood, with the result that the feces become dry and hard and constipation is complained of. When more fluid is taken by mouth more urine is passed and the excretion of waste productions through the kidneys is facilitated. Many of those who lead sedentary lives drink fluid only at meals, except in warm weather or after vigorous exercise. Though there is in general no objection from the hygienic standpoint to drinking as much as a glass or two of water with meals, still it is preferable to drink the water when there is no food in the mouth to be chewed; in other words, water should not be used "to wash the food down." A glass of water on rising in the morning and one an hour before the midday and the evening meal, in addition to the fluid that is taken at meal times, is often helpful in overcoming constipation. The quenching of thirst between meals by means of nourishing drinks (milk, chocolate, cocoa) is to be discouraged in persons who manifest a tendency to overnutrition, though the practice may be helpful to the undernourished, provided the appetite for the regular meals be not thereby impaired.

CHAPTER IX

CARE OF THE EXCRETORY CHANNELS

Digestion and Absorption from the Alimentary Tract and their Hygienic Importance.—The act of mastication is purely voluntary. The initiation of the process of swallowing is also voluntary, though it is completed automatically. Similarly, the act of defecation is partly voluntary and partly involuntary. All the rest of the muscular and secretory activities involved in digestion are automatic and are entirely beyond our voluntary control. One's personal hygienic responsibility as regards the digestive system, therefore, is related chiefly to the choice of the quality and quantity of food and fluid to be ingested, the thoroughness of mastication, the initiation of the swallowing movements, and the regular inauguration of the process of defecation, which rids the body of some of the refuse of food materials together with bacteria and substances that have been excreted into the large intestine.

The stomach is a large muscular pouch which receives the food as it is swallowed, holds it for a while, churns it up, mixes it with the gastric secretion, and, at the proper time, permits it to pass through its lower opening (pylorus) into the small intestine. If the food has been properly chewed and thoroughly mixed with saliva, a certain amount of digestion of the starchy food will occur, through the action of the ferment (ptyalin) that is secreted by the salivary glands. This preliminary digestive process goes on while the food is in the stomach and before it has become intimately mixed with the stomach juice. After the latter admixture occurs, the complex protein substances in the food are broken up by means of the pepsin and hydrochloric acid of the stomach

juice into somewhat simpler compounds (proteoses and polypeptids). The stomach contents are thus changed to a semi-fluid acid material, which is spurted at intervals through the pylorus into the small intestine, where in turn it becomes mixed with the secretions of the small intestine (succus entericus) and with those of the pancreas (pancreatic juice) and of the liver (bile). Digestion is merely begun in the stomach; very little absorption from this organ occurs. Digestion and absorption go on chiefly in the long, small intestine, although the contents pass through the tube rather rapidly. Within from four to six hours after eating, the portion of the meal not already absorbed passes, still in fluid form, through the ileo-cæcal opening into the large intestine (colon), where it remains for many hours.

Digestion continues to go on in the large intestine through the activity of the ferments brought there with the food from the small bowel and also through bacterial action, which seems to be of much more importance here than elsewhere in the intestinal tract. A good deal of absorption of water and of the products of digestion occurs, too, in the large bowel, so that when the residual material reaches the rectum it is, normally, a much reduced, soft, solid mass. Owing to the strong acid reaction of the juice secreted by the stomach, bacteria cannot thrive there. Indeed, many of the bacteria taken in with the food are killed in the stomach, and this destruction of bacteria by the stomach juice constitutes one of the important defense mechanisms of the body against bacterial infection. Under normal conditions bacteria do not multiply markedly in the small intestine; they are present, however, in great numbers and variety in the large intestine (colon). They live upon and digest the products of proteins and are responsible especially for the so-called putrefactive processes. They break up the proteins even more completely than do the digestive ferments of the body themselves, with formation of simpler compounds (indol, skatol, hydrogen sulphid), which give rise to the characteristic unpleasant odor of the stools. Many of these substances resulting from

the putrefactive action of bacteria are absorbed from the colon into the blood stream and are carried to the liver, where they are combined (or "conjugated") with acid radicals (sulphuric acid); reaching the kidneys, they are excreted in the urine in the form of the so-called "conjugated sulphates" or "ethereal sulphates." The amount of these sulphates in the urine is often considered a fairly satisfactory index of the extent of the putrefactive processes in the large intestine.

Some years ago one heard, and read in medical literature, a great deal about "auto-intoxication," by which was meant, usually, the absorption from the intestine of the products of protein putrefaction and the poisoning of the body by them. Metchnikoff went so far as to teach that involutional processes in general are due to this cause and that health could be subserved and old age deferred through the combating of putrefaction in the intestinal canal by eliminating animal proteins from the diet and by replacing the putrefactive bacteria with Bulgarian bacilli (obtainable in a certain type of sour milk). Sour milk and tablets containing these bacilii were very popular for a time, especially as a great variety of ailments were ascribed to "auto-intoxication." The fad went to such an extreme that it finally became ridiculous, since when many physicians have been almost ashamed to use the term "auto-intoxication." The pendulum, as it so often does, swung to the other extreme and it was generally denied that intestinal putrefaction had any great importance in the production of disease. It is probable that the truth lies somewhere between these two extremes. We know that the intestinal tract of man and of all animals, although sterile at birth, remains sterile for only a very short time, and that, under ordinary conditions, the human colon swarms with bacteria, inclusive of putrefactive organisms. Certain poisonous substances may be, and probably are, absorbed from the colon, especially in the circumstances of colonic stasis and chronic constipation. Hence it has become a cardinal principle of hygiene to avoid constipation, to culti-

vate a regular habit of evacuation of the large intestine once or twice a day. Under natural conditions of eating and of exercise out-of-doors there will usually be little difficulty in securing regular bowel movements. Under unnatural conditions (concentrated diets; sedentary habits) constipation is very prevalent and is likely to be accentuated by nervous factors incident to the stress and strain of modern life. Laxative medicines and enemas afford temporary relief, but when they are constantly resorted to they impair the function of the wall of the bowel and natural bowel movements cease without their aid. Nature's remedies for constipation are much the best. Anyone, in the absence of severe organic disease, can train the bowel to satisfactory excretory efficiency by the exercise of due care, including attention to the five following measures: (1) diet suited to the individual in atonic constipation bulky foods (green vegetables, fruits, bran) are helpful, whereas in spastic constipation a non-irritating diet with purèe vegetables for a time may be desirable; (2) the drinking of sufficient quantities of fluids (in health, two quarts daily); (3) the cultivation of a regular habit of going to stool at a certain hour each day regardless of inclination; (4) adequate physical exercise; and (5) if necessary, in addition to the bulky diet, an intestinal lubricant in the form of a heavy mineral oil, best taken at night in fairly large doses of one-half to one ounce. Usually after a regular habit has been established the dose of the oil may be diminished or eliminated entirely. As a dietary aid, one may use agar agar mixed with a cereal or other food. This product of Japanese seaweed absorbs water in large amounts and thus adds considerably to the bulk of the feces.

The Kidneys from the Hygienic Standpoint.—The secretory activity of the kidneys is entirely automatic although the emptying of the urinary reservoir or bladder is under voluntary control. Although the direct formation of urine is purely automatic, we can indirectly influence the amount of urine markedly by the amount of fluid we drink.

Water is the best of all diuretics. The amount of water

ingested determines to a great extent the amount of urine secreted except under unusual conditions when larger amounts of fluid are lost through excessive sweating or diarrhoea.

The urine consists largely of water. Other substances dissolved in it are sufficient in amount to raise its specific gravity (i.e. its weight compared with water) from that of 1.000 for water to 1.010 or 1.020 for urine. In the urine are excreted chiefly the final products of protein and purin metabolism (urea, uric acid, ammonia, creatinin), certain inorganic acids and bases, and certain pigments derived from different sources in the body. Under abnormal conditions still other substances may be found in the urine, for example, albumen (derived usually from the blood serum), sugar (indicating as a rule an excess of sugar in the blood), minute microscopic casts of the urinary tubules, pus and bacteria (indicating an infection in the urinary tract), and sometimes blood cells. By examination of the urine, the physician may obviously, therefore, secure useful information in a number of different diseases.

As a rule the body does not suffer from the loss of substances that are passed out in the urine. It is rather the opposite; the retention in the body in certain amounts of substances that should be excreted leads to poisoning of the body through the presence of an excess of waste products in the blood (uraemia). In a subsequent section we shall show the great importance of the functions of the kidneys in connection with certain degenerative diseases. Although these organs possess an enormous reserve power over and above the amount of work they are usually called upon to do, hygienic prudence demands that this reserve power be conserved in every practicable way. This conservation, like the prophylaxis of many degenerative states, depends upon attention to a wide variety of hygienic principles, including, (1) the avoidance of possible sources of infection or their eradication, (2) the general prophylaxis of acute and chronic arterial diseases, (3) proper professional attention to ab-

normalities of the lower urinary tract (prostate, urethra, bladder, ureters) when these exist and (4) adherence daily to a dietetic and hygienic regimen that subjects these important excretory organs to minimal strain. In view of the wide range of capacity of kidney function under normal conditions, it is probable that the first three factors above enumerated are more important than the fourth. The matter will be given consideration later on in appropriate sections.

As far as food is concerned, it would be a counsel of perfection to advise that the protein intake should never be in excess of what would correspond to 10 per cent of the total caloric value of the diet, for this would mean eating much less meat than the majority of us are accustomed to eat. By such a limitation of protein in the diet we could avoid an excess of urea and other protein "ash" to be excreted by the kidneys, and there would be less likelihood of excessive putrefaction of the proteins in the large intestine and consequently fewer products of putrefaction to be eliminated in the urine. For the protection of the kidneys we may also reiterate here a warning against excessive use of salt and of salty foods.

Clinical experience indicates that the kidneys may continuously secrete enormous amounts of water, even for years, without suffering material damage therefrom, as has been shown in cases of diabetes insipidus. Water drinking may, however, be overdone; there is no advantage in drinking, as some persons do, very large amounts (15 to 20 glasses a day); indeed, for patients suffering from diseases of the heart, the blood vessels, or the kidneys such copious water drinking may be actually harmful. Most of those who lead sedentary lives, however, are inclined to drink too little water; as a consequence, they force the kidneys to secrete too concentrated a urine. Normal persons will do well to make their daily intake of fluids equivalent in amount to six or eight glasses of water.

Abuse of alcohol may be a factor in the development of

kidney disease, as may also intoxication by mineral poisons (lead, mercury, arsenic). As we shall see in a later section, among the worst forms of injury to the kidneys are those that develop as complications of certain infectious diseases (scarlet fever, tonsillitis, streptococcus sepsis).

CHAPTER X

BACTERIAL POISONS

It is in the fight against infectious diseases that, in our time, sanitation has scored some of its greatest triumphs; it is to achievements in this field of hygiene that we owe most of our increase in the expectancy of life compared with that of a century ago. Bacterial infection may cause death quickly in an acute illness, or it may sow the seeds of premature degenerative changes in the bodies of those who recover from the acute disease. Not only may obvious and dramatic infectious maladies like diphtheria, measles, scarlet fever, typhoid fever, pneumonia, meningitis, tuberculosis, and syphilis inaugurate degenerative processes in the arteries, the heart muscle, the kidneys, or the nervous system, but more insidious maladies, of the existence of which the patients may be quite unconscious, may be responsible for very serious sequels. Thus, focal infections about the roots of teeth, or at the margin of the gums, may give rise to no pain or discomfort, and yet may exert most harmful effects upon distant parts of the body. Certain other focal infections that are at times associated with obvious local manifestations (sore throat, tonsillitis, running ears, infected gall bladder) may apparently be recovered from, and yet a low-grade infection may continue to exist; the acute attack may be entirely forgotten, and yet toxins may be given off over a long period and lead gradually to degenerative changes in distant organs or tissues.

Health departments are now waging with success a constant warfare against the acute infectious diseases. There is no department of medicine, perhaps, that has attracted more able research workers. New discoveries are ever being

made and new methods are being devised for eliminating, or for mitigating, the ravages of these diseases. All this work would have been greatly hindered if legislation against animal experimentation had been passed. There is a small group of misguided and militant enthusiasts constantly lobbying for anti-vivisection legislation; they constitute a real menace to the advance of sanitation and of the science and art of medicine in general.

A marked degree of success has been attained already in the prevention of many of the infectious diseases. Vaccination (with cowpox) has so robbed smallpox of its former terrors that there is real danger that people, owing to loss of fear or of thought of the disease, may neglect this simple precaution. If an unprotected population should grow up, the conditions favorable to widespread epidemics of smallpox would be reverted to. Mild cases of smallpox may occur here and there and they would serve as the starting point of severe epidemics if there were many people unvaccinated. The Montreal outbreak (in 1885) was of this type. Many of the population of that city had been opposed to vaccination and the prophylactic custom had fallen into disuse. A case of smallpox was imported from a neighboring city of the United States and within nine months some 3,164 people died of the disease in the city of Montreal alone!

The mortality from diphtheria has been greatly reduced by the use of anti-diphtheritic serum as a treatment of the disease, and the newer preventive method by means of injection of small doses of a mixture of toxin and antitoxin, with production of an active and lasting immunity, is apparently as simple and as effective as is vaccination against smallpox. This immunizing procedure against infection with the diphtheria bacillus is not dangerous; it does cause even the discomfort incident to vaccinia. Every child, found on applying the Schick test to be susceptible to diphtheria, should have the benefit of this prophylactic measure.

It should be emphasized that, though public health

authorities are ever active in fighting infections in general, the responsibility for the utilization of the known preventive measures (general and special) dare not be ignored by lay individuals or by general practitioners of medicine. Unless the heads of families and family doctors take a deep interest in preventive measures, many unnecessary infections will occur and many lives will certainly be lost that might easily be saved. Although there are some compulsory vaccination laws, these laws are by no means general, and even where the laws exist they are too often disobeyed. The value of the toxin-antitoxin mixture in the prevention of diphtheria has been too recently demonstrated to permit as yet of legislation for compulsory observance of this protective measure.

Typhoid fever has decreased greatly in incidence during the past two decades, owing chiefly to improvements in methods of sewage disposal, water filtration, and chlorination and regulations regarding the milk supply. An antityphoid vaccine of considerable potency is also now available; it can be highly recommended to those whose duties especially expose them to the disease (physicians and nurses) and to those who must live in or visit communities in which the disease is prevalent. Protection against infection is afforded by three injections of this vaccine given at intervals of about one week; severe reactions from the injections are uncommon. The protection given is believed to persist for several years. The vaccine now used is protective not only against typhoid fever, but also against the two varieties of paratyphoid fever.

Great advances are being made also in the prophylaxis of malaria by eradicating mosquitoes from infested communities. Individuals in such communities may aid the campaign greatly by screening themselves from the infecting insects (mosquitoes) and by taking small prophylactic doses of quinin.

Measles ranks first as a cause of death among the acute eruptive fevers of children and is particularly dreaded in children's hospitals because of its highly contagious nature.

It is particularly fatal in very young children, and it is especially to be desired that some specific prophylactic measure be devised to protect those of two and three years of age, as well as older children whose vitality is impaired. At present the blood serum of patients convalescent from measles is being used to confer a passive immunity upon children who have been exposed to the disease and very favorable results are being reported.

A prophylactic vaccination against whooping cough is now available. It is a harmless and painless procedure and would seem to be well worthy of trial in children who have been recently exposed to the disease.

The serum used in the treatment of epidemic cerebrospinal fever (meningitis) has been of distinct value, though it is not as powerful as the diphtheria antitoxin. A prophylactic vaccination against cerebrospinal meningitis has also been employed, but it has not as yet been used in a sufficiently large number of persons to demonstrate its usefulness conclusively.

The value of the use of vaccines in the preventive of the so-called "common cold" in the head has been the subject of considerable recent controversy. These vaccines are made from cultures of several of the different bacteria that may at times be associated with upper respiratory infections, and if a person's colds are caused by one of these organisms the method would seem to have a rational basis. There is a growing belief, however, that most of the "common colds" are due to an infective agent so small as to be beyond the power of our present microscopes to make visible; for colds due to such an ultra microscopic virus, the use of the commercial vaccines now in vogue is valueless except that perhaps they may increase resistance by stimulating the production of non-specific immune substances. Careful examinations of those who suffer frequently from "colds" often reveal foci of chronic infection in the tonsils, in adenoids, or in the paranasal sinuses; the most rational prophylaxis in such instances lies in the removal of the chronic focus of infection.

Just here, however, it should be pointed out that the doctrine of the importance of focal infections has in some instances been carried to an extreme; it must be admitted, too, that many teeth and tonsils (not infrequently uninfected teeth or tonsils!) have been needlessly removed. But because the attempt to find and to remove foci of infection has become a fad is no reason for throwing the whole idea of focal infection and of the serious consequences that follow it into the discard. Even very conservative physicians are now thoroughly convinced of the importance, for actual or potential damage to other tissues, of small areas of infection in the tonsils, in adenoid tissue, in the paranasal sinuses, in the middle ear, in the gums, about the apices of teeth, in the bronchi, in the gall bladder, and in the genito-urinary tract. Surgical or medical treatment of such areas of focal infection as are discovered should be based upon careful and competent diagnostic examinations and upon a consideration of the patient as a whole as well as of the local lesion.

Attempts of experimental pathologists to reproduce in animals the pathological lesions found in certain of the human degenerative diseases (*e. g.*, cirrhosis of the liver, chronic nephritis, arteriosclerosis) have met with variable success. Some of the most successful positive experiments have resulted from the prolonged use of bacterial poisons combined with other poisons, such, for example, as bacterial toxins with phosphorus, or bacterial toxins with uranium nitrate. These observations lend strong support to the view that general and focal infections may be important factors in the causation of some of the degenerative diseases of man.

Long-continued tuberculous infection is a potent factor in the production of certain degenerative states. The extensive campaign against tuberculosis is making satisfactory headway; at any rate, the incidence of the disease has been steadily declining for a number of years.

Syphilis is doubtless of more importance in connection with the origin of certain degenerative states than is any other single infection. The organs of the circulation and of the central nervous system are attacked with especial

frequency, in both the early and the late stages of this disease, with the production of degenerative as well as of inflammatory lesions. The stigma and the secrecy attaching to syphilis because of its venereal relationships are handicaps to efficient public-health preventive activities. Prophylactic measures against syphilis include (1) the proper education of youth concerning the dangers of sexual promiscuity, (2) chemical prophylaxis after sexual intercourse for those who insist upon running into danger, and (3) the early recognition and vigorous treatment of initial lesions.

Generalities Concerning the Prevention of Infectious Diseases.—In the prevention of infection in general, there are two fundamental principles to be observed: (1) that of avoidance of contact with the infectious agent (germ) and (2) that of increasing personal resistance to infection by keeping one's physical health at the highest possible level, so that, even though harmful germs are encountered, they are killed off quickly in the body and serious infection does not occur. The first principle leads us to attack the germs themselves and to prevent the transfer of the germs from persons already infected by them or from healthy germ-carriers; the second principle is applied by adopting the well-recognized measures of personal hygiene.

The greatest success has been attained in campaigns against those infections the causes of which are susceptible of direct attack. We now know, for example, how to combat typhoid fever, dysentery, and cholera, for we know that the germs that cause them are ingested with our food and drink. We can fight yellow fever and malaria successfully because we know that they are transmitted by the bites of infected mosquitoes. Quarantine of infected persons, fumigation of sick rooms, disinfection of excreta, purification of water and food supplies, proper sewage disposal, are among the methods now used as direct measures against the causes of infections.

Despite all our precautions, however, a great many

bacterial and protozoan enemies get beyond the extra-personal barriers. Some of them gain admission through the gateway of the respiratory tract, some through that of the digestive tract, some through the genito-urinary tract, and some through minute injuries to the skin. Special methods of defense (vaccination, immunization) are available against some infections, as we have already noted for smallpox, diphtheria, and typhoid fever. But our main reliance must be placed upon a general strengthening of the "secondary defenses" (raising of resistance to the highest possible level) by means of the whole aramentarium of euthenics—that is to say, by means of good food, plenty of water, regular habits, fresh air, suitable clothing, proper regulation of work, play, rest, and exercise, avoidance of extreme fatigue, mental and social hygiene, and systematic examinations by competent physicians not only for the treatment of existing ailments, but also for purposes of prophylaxis.

Before the last-named procedure can become effective both the medical profession and the general public must become awakened to an interest in its possible advantages. Examination of recruits for the armies of the World War showed that approximately one-third of these young men exhibited physical defects of sufficient gravity to bar them from military service. Under ordinary conditions the somewhat perfunctory examinations for life insurance are the only ones that at present reach large numbers of people. These examinations have been of such great value to many men in bringing to light conditions of the existence of which they were totally unaware that it is rather surprising that the idea of "periodic health examinations" has been so slow of adoption. The Life Extension Institute is doing good work in encouraging the custom of more frequent medical examinations for the presumably healthy. A great many men and women are already in the habit of paying regular visits to their dentists, and occasionally an intelligent man requests an examination by his family physician or resorts

to a diagnostic group for a periodic general diagnostic survey. Unfortunately, busy practitioners have not always been as sympathetic with preventive as with curative medicine, but of late a gratifying change of attitude in this regard has become recognizable.

CHAPTER XI

EXTRANEOUS POISONS OTHER THAN BACTERIAL

Alcohol and Tobacco.—Concerning these substances, very delectable to some people, very horrible to others, their use sometimes a pleasure, sometimes a vice, prejudice plays the greatest part in the formation of opinions as to their value, on the one hand, and as to the damage they inflict, on the other. There is, however, little if any difference of opinion as to the evil results of their excessive use; the controversy rages over the question of the admissibility or advisability of moderate indulgence.

Osler has said, "In moderation, wine, beer, and spirits may be taken throughout a long life without impairing the general health." Pearl's statistical studies, based upon an adequate material, seem to demonstrate that the moderate use of alcohol does not shorten the average duration of life, although its excessive use shortens it by several years. His study, however, considers only the effect of alcohol upon the duration of life, it does not take into account the economic, social, and psychic factors involved.

Used in excess, both alcohol and tobacco are undoubtedly poisons to the human body, but so are other substances (*e. g.*, drugs) which when taken in small doses may under certain circumstances be very beneficial. That there are factors of personal equation to be considered, that different reactions to alcohol and tobacco are manifested by different people, is now well known. One person may be apparently "stimulated" by an amount that renders another "stuporous." A cirrhosis of the liver may follow comparatively moderate drinking in some cases, though there are heavy

topers who may escape any liver injury. It cannot, therefore, be safely predicted what will constitute moderate drinking for one man or excessive drinking for another. The wide distribution of alcohol and tobacco and the temptations that may be associated with their use put these substances in a class by themselves, apart from other drugs. Human beings can undoubtedly "get along" without either of them, and the human body will, ordinarily, suffer no harm from abstinence.

In the opinion of most physicians, the parts chiefly affected by chronic alcoholic poisoning are (1) the *nervous system,* resulting in muscular tremors, dulled mentality, irritability, forgetfulness, moral delinquencies, impaired judgment, enfeebled will, dementia, insanity; (2) the *digestive system,* with catarrh of the stomach or chronic gastritis, impaired appetite, constipation, and fatty and cirrhotic liver; (3) the *circulatory system,* with degenerative changes leading to arterio-sclerosis; (4) the *immunity processes* of the body in general through which bacterial invasion is combated. There is less unanimity of opinion in regard to its effects upon (5) the *kidneys.* Some laboratory workers doubt the justification of these "clinical impressions," since laboratory experiments have not consistently supported them. It is extremely difficult, however, to reproduce the condition of chronic alcoholism satisfactorily in the laboratory; and, moreover, one must be very cautious in applying the results of animal experimentation in such cases to human beings. Statisticians also assert that these clinical impressions are not based upon satisfactory statistical material from a scientific standpoint, an objection that is undoubtedly valid.

Something has already been said in this treatise of the experiments bearing upon the effects of extreme alcoholism in animals upon the germs cells and its importance for the development of individuals arising from those cells. The reader is referred, therefore, to an earlier chapter for comments upon these experiments.

According to Rosenau, "The strongest indictment against

alcohol is that it excites the passions and at the same time diminishes the will power. The fact that alcohol lowers moral tone does much more harm than all the cirrhotic livers, hardened arteries, shrunken kidneys, inflamed stomachs, and other lesions believed to be caused by its excessive use."

The harmful effects of excessive use of tobacco or of its more moderate use in especially susceptible individuals are exerted also chiefly upon the nervous system. Muscular tremors are not uncommon, with the result that delicate movements are less satisfactorily performed. Comparative experiments seem to indicate that, in excessive smokers, there is a loss of vigor and energy and a general impairment of both mental and physical ability. One of the forms of toxic amblyopia (dimness of vision) has for a long time been ascribed to tobacco poisoning. During the earlier stages of the malady no organic nerve changes can be demonstrated, but later on, if the condition persist degeneration or atrophy of the optic nerve becomes apparent. Through its effect upon the autonomic nervous system tobacco causes symptoms referable to different organs of the body. For example, many smokers complain of "heart burn" due to too much acid in the stomach (gastric hyperacidity), especially after the use of tobacco when the stomach is empty; others are inconvenienced by excessive sweating, especially of the hands and feet; still others experience an increased pulse rate, a sensation of pounding of the heart, and of breathlessness on exertion. Frequently irregularities of the heart beat are ascribed to tobacco.

The upper respiratory tract (the pharynx and larynx especially) is often irritated by tobacco smoke, which produces a redness and dryness of the mucous membrane and a more or less disturbing cough.

The manifestations on the part of the circulatory system may be due chiefly to the poisoning of the sympathetic nervous system already mentioned. Besides its effect upon the heart through this mechanism, a number of physicians

have believed that tobacco has an especially harmful action upon the arteries and that it is one of the important causes of arterio-sclerotic changes. The condition of "limping leg" (intermittent claudication) seems to have occurred especially often among excessive smokers.

The use of chewing tobacco especially has been considered a cause of a chronic irritation of the lining of the stomach (chronic gastritis).

From a purely scientific standpoint the study of the effects of tobacco poisoning has been even less satisfactory than that of alcohol. It is well known that tobacco contains a powerful poison, nicotine, but the question has been repeatedly raised as to whether its effects on the human system are due to the nicotine. Certainly nicotine can be absorbed only in small traces, since, as we have said, it is a very powerful poison. Most of the experiments designed to demonstrate the physiological action of tobacco have been continued over very short periods of time and they can give but little information concerning the effects of its prolonged use.

Tobacco is undoubtedly a poison. The liking for it must be acquired by gradually increasing its use and not infrequently at the expense of marked discomfort from the effects of acute poisoning. The result of indulgence in tobacco is generally considered to be particularly deleterious in youth. There are few people with any interest in hygiene who would not discourage the beginning of the habit in youth, but many physicians think it unwise to advise older people to stop smoking entirely if they have been addicts for a long time. The habit becomes firmly fixed and is broken with considerable difficulty. Such patients are often advised to limit the smoking to three or four times a day or to avoid smoking at all before midday.

The relationship between the use of tobacco and the commoner degenerative diseases is largely a matter of conjecture, but the occurrences of toxic amblyopia and ultimately of optic nerve atrophy, of chronic gastritis, and of a

continually abnormal excitation of the heart, make the supposition of a relationship at least plausible. Whatever may be the pleasure and solace of moderate indulgence in alcohol and tobacco, it must be admitted that they are scarcely commensurate with the potential dangers of over-indulgence, save perhaps for him who is chiefly interested in a "short life and a merry one" rather than in longevity.

Mineral Poisons.—A large number of mineral poisons are of importance in connection with the so-called "industrial diseases." The most important of these poisons for the origin of degenerative diseases are lead, mercury, and arsenic, and especially the first named, for lead is encountered in many different industrial processes and causes pronounced degenerative changes in the nervous system, in the blood, in the arteries, and in the kidneys. Most of the mineral poisons are inhaled as fumes or dust or are swallowed with contaminated food or drink. Governmental regulation of dangerous occupations, with the introduction of improved methods and safety appliances, has done much toward minimizing the dangers from mineral poisoning; but these dangers are still very real in many industries. As a general rule it is the manufacturer's responsibility to furnish the special methods of ventilation, adequate facilities for washing, mess-room accommodation, special protective clothing, cleanliness of workrooms, and prohibition of bringing food and drink into workrooms; and it is the workman's responsibility to abide by the rules made for his safety, to exercise due care in the thorough cleansing of hands and other exposed skin areas, especially before touching food or eating it.

CHAPTER XII

ENDOGENOUS POISONS

ENDOGENOUS poisons arise from within the body and are formed by the body's own metabolic processes. Normal and abnormal metabolism are just now subjects of the greatest interest in scientific medicine. Though a great deal has been found out about them, much remains still to be discovered. We have already emphasized the importance for the degnerative diseases of some of the disordered metabolic states, especially over-nutrition, diabetes, gout, and thyroid disturbances. The relationship between these conditions and degenerative states has been definitely established and it seems probable that other disturbances of metabolism of which we now know very little may also be of importance in the etiology of degeneration. In general, from the standpoint of euthenics, the metabolic disorders require the services of a physician for diagnosis and for treatment, for, even though they may not be curable, they are to a certain extent amenable to treatment and many of the serious degenerative sequelæ may be avoided or postponed by the proper management of the case in its earlier stages. Here we have another argument for the importance of regular medical examinations if we are to get the full benefit of preventive medicine; for through periodic diagnostic surveys many of these conditions may be detected much earlier than would otherwise be the case.

A brief classification of some of the metabolic disorders capable of accelerating or of inaugurating degenerative changes may here be presented:

(1) Changes in general nutrition (over-nutrition; under-nutrition).

(2) Special dietary-deficiency diseases (such as scurvy, beriberi, and pellagra).

(3) Anomalies or defects of protein metabolism (for example, the appearance of amino-acids like leucin and tyrosin in the urine in certain degenerative diseases of the liver) and disturbances in the metabolism of the purin bodies from which uric acid is formed (for example, gout).

(4) Disturbances of carbohydrate metabolism (*e. g.*, diabetes mellitus).

(5) Disturbance of fat metabolism (*e. g.*, acidosis due to the formation of toxic acid products from fat in diabetes mellitus as the result of an incomplete oxidation of fat).

(6) Disturbance of water metabolism (*e. g.*, diabetes insipidus).

(7) Disturbance of mineral metabolism (*e. g.*, of calcium in tetany, in certain bone diseases, in the formation of calculi or stones and in degenerated areas of arteries and other tissues; of phosphorus in certain similar conditions; of iron in anæmia; of iodin in thyroid disorders; of sodium chloride in edema or dropsy).

(8) The retention in the body of substances that normally are excreted (*e. g.*, uremia due to inability of the kidneys to perform their function).

(9) The absorption of dead or degenerated material in excess (as after an extensive burn, or during the "resolution" of the inflammatory products that have solidified a part of the lung in pneumonia).

(10) The accumulation of the products of over-activity (as has been especially demonstrated in muscular overstrain —*i. e.*, a condition in excess of ordinary fatigue).

(11) Disorders of the glands of internal secretion (*e. g.*, of the thyroid in exophthalmic goiter, toxic adenomata or hypothyroidism; of the parathyroids in tetany; of the hypophysis or pituitary body in acromegaly or in hypopituitarism; of the adrenals or suprarenals in Addison's disease; of the sex glands or gonads in premature puberty or in eunuchoidism; and of the pancreas in diabetes mellitus).

This classification, which overlaps somewhat, indicates some of the different ways in which the physico-chemical processes of the body may vary from the normal to such an extent as to constitute disease. It does not, however, attempt to give the ultimate causes of the variations; some of these are known, though others are still obscure.

The study of the glands of internal secretion (endocrinology) has excited widespread interest during the past decade. The discoveries that some of these secretions are absolutely necessary for life (adrenals, pancreas), that several of them are necessary for proper growth and development (thyroid, parathyroids, pituitary, gonads), and that certain important diseases are correlated with lesions in the endocrine glands, have led some over-enthusiastic physicians to ascribe to endocrine influences most, if not all, of the phenomena of disease that have hitherto remained unexplained. This over-abundant enthusiasm of members of the medical profession and of the laity has made conservative physicians realize the necessity of scrutinizing very carefully each heralded new development in this interesting field. Researches in this domain are now being actively pursued and scarcely a month passes without its quota of alleged endocrine discoveries. A few of them have proved to be sound when subjected to rigid scientific test; the most notable recent contribution of this type is the development of a method by Canadian workers (Banting, McLeod, Best) by which the internal secretion of the pancreas (insulin) has been made available for the successful treatment of diabetes mellitus. Not that insulin "cures" diabetes; it does, however, tremendously alleviate suffering and wards off dangers in the graver cases. Many claims of endocrine discoveries are made that are not substantiated or for which the evidence as yet is insufficient or inconclusive. Among the hypotheses that should be considered with great caution are some of the suppositions that attribute to the endocrine glands the predominant influence in the production of the involutional changes associated with "growing old."

We do know that from certain changes in the thyroid, in the pituitary gland, or in the sex glands, obesity may result and we also know that obesity is a factor of some importance for the origin of certain degenerative states. We know, too, that a deficiency of the internal secretion of the pancreas is associated with diabetes mellitus and that this in turn is usually accompanied, in chronic cases, by degenerative changes, especially in the arteries. We have further very good reasons for believing that certain thyroid disorders are associated with definite degenerative processes in the heart and in the arteries. On the other hand, it may be that the vascular aplasia seen in Addison's disease (a disease of the suprarenal glands) is an associated constitutional phenomenon rather than a result of the glandular disease. Again, certain resemblances between the effects of hyperthyroid states and the appearance of youth and the similarity of the effects of hypothyroid states (cretinism and myxœdema) to the appearance of age have led some writers to ascribe by analogy the changes of senescence to a gradual atrophy of the thyroid gland, but this suggestion has not, as yet, received the stamp of full scientific approval.

By far the most widespread public interest in this connection has been aroused in a supposed relationship between age and the functional activity of the endocrine portions of the gonads or sex glands (the testes and the ovaries). Relatively early in the development of endocrinology, a famous physiologist, Brown-Séquard, asserted that he had brought about a considerable rejuvenation in his own person by the subcutaneous injection of testicular extracts, that he "at the age of seventy recovered the force and energy of youth, with manifestations unknown for a number of years." He died some four years later. In recent years the experiments and writings of Steinach, of Voronoff and others have greatly popularized this idea and have made the topic of "glands" a favorite one in the Sunday supplements of the press and even the background of popular novels. Steinach has asserted that by simply ligating, or tying off and cutting,

the vas deferens, the channel from the testis to the exterior, he can cause the seminiferous tubules, the portion of the testis in which the spermatozoa are formed, to undergo atrophy and at the same time cause the interstitial cells to undergo hypertrophy. These interstitial cells, that lie between the tubules that produce the sperm cells, are believed to be the source of the internal secretion of the testis. Through this simple ligation procedure he has reported the "rejuvenation" of a number of animals and of men. His experiments and clinical observations require more confirmation than they have as yet received. Some of the investigators who have repeated portions of his work believe that any beneficial results of his operation are at best of short duration; in man, at least, they may be due largely to the psychic effects of the procedure.

Many experiments have been done in the transplanting of glands, both testes and ovaries, with reports of some very striking results, especially in lower animals. Transplants must be taken from an animal of the same species as the one in which the tissue is to be placed. Most surgeons have found that such a graft, even if at first it seem to "take," very soon degenerates, atrophies, and disappears. Among human beings the difficulty of securing material for transplantation, if nothing else, would make the procedure a rare one. Every now and again the newspapers contain a thrilling account of the forcible capture and involuntary removal of a sex-gland for transplantation!

However facinating the idea of our becoming able in any measure to control directly the processes of degeneration and senescence may be, it must be admitted that our knowledge of endocrinology is still far too imperfect to permit of positive statements on the subject. Indeed, it is very doubtful if there be much hope of practical accomplishment in this direction.

CHAPTER XIII

PSYCHIC AND SOCIAL FACTORS

THE mind makes the man. Psychic factors are present in almost every illness; indeed, they predominate in many of the illnesses for which patients consult physicians and are, accordingly, responsible for a large share of human suffering. Though it is true that many "nervous" people reach a ripe old age, it nevertheless seems quite certain that in some cases at least the nervous element induces changes in the functions of the body of such a nature that a severe strain is imposed upon the tissues affected by those functions, with the result that degenerative changes ensue. Stated in another way, organic, structural changes may sooner or later accompany what at first was a "functional" nervous trouble. This applies particularly to those degenerative changes in the arteries that accompany abnormally high blood pressure, which may apparently be induced by emotional factors operating through the autonomic nervous system, or, more specifically, through the vasomotor nerves (the portion of the autonomic system that controls the contraction and expansion of the small arterioles).

Now the "tone," or degree of contraction maintained in the muscular coats of these small twigs, is one of the important means by which the blood pressure or pressure of blood within the arterial tree is kept up. The other factors in its maintenance are (1) the contractile power of the heart and (2) the elasticity of the walls of the arteries. Normally, the relationship between the heart's action and the degree of tone of the small arterioles is very delicately adjusted, and this power of adjustment constitutes a marvelously effective mechanism for the maintenance of the circulation

in general and also for furnishing the proper supply of blood to different parts in amounts corresponding to the needs of those different parts at different moments. Thus the general blood pressure varies, becoming higher or lower during the day according to the demands made upon the circulation. Not only are the arterioles under nerve control, but the heart is also; it is supplied by similar nerve fibers and is subject both to stimulation and to inhibition by emotional influences. In the opinion of eminent scientists certain emotions are, within physiological limits, important mechanisms of defense in many animals as well as in man. Thus fear or rage causes the heart to beat faster and the blood pressure to rise; the whole body is put on the *qui vive,* ready to fight or to fly from danger. In mildly abnormal mental states, especially in those associated with anxiety, with many fears, with worry, or with fretting, a general nervous tension that keeps the body as a whole and the autonomic nervous system in particular keyed up to a high pitch, these nervous factors may be conducive of a condition of chronic high blood pressure within the arteries. In such instances there may be no evidence of organic change in the arteries or in the other tissues for years, but sooner or later the strain tells and degenerative changes set in, the time of their onset depending in part upon the innate strength of the arterial system and in part upon the mode of life of the individual.

As we have already intimated, not only the strength of our arteries, but also the type of our nervous system, is largely pre-determined by heredity. We have to do the best we can with the materials given us by inheritance. It is safe to say that the care and training that the nervous system receives will be reflected in the arteries later in life. In the contemplation of a family of nervous, ill-trained parents with nervous, ill-trained children, it is often very difficult to tell what part of the behavior of the offspring is due to bad heredity and what part to bad psychic-contagion. Doubtless, in most cases, both factors are important. The hered-

itary factor in an individual is beyond hygienic endeavor (as far as an individual already existent is concerned), but the psychic-contagion factor is amenable to management, and the earlier this is undertaken the more sanguine we may be of its beneficial results.

It is trite to say that each child differs from every other, but it is important to emphasize this truism. The child's training, especially that important portion of it that is received in the home, should be individualized. The sluggish, the careless, or the happy-go-lucky child or youth may be stimulated by such good old maxims as, "Never put off till to-morrow what you can do to-day," and, "In the bright lexicon of youth there is no such word as fail"; but the anxious, fearful, ambitious, over-conscientious child needs entirely different advice. He should be taught some of the calmness of Oriental philosophy, and induced to assume more of the "Why worry?" or the "What of it?" attitude. Show him the wisdom *for him* of putting off till to-morrow what he could only by straining do to-day. A young person of the latter type may be benefited by emphasis upon the adage that "what we fear may happen seldom happens."

Too often the inculcation of such suitable ideas is postponed until in adult life symptoms have arisen because of the patient's maladaptation to the situations and circumstances of his life. Then, it is less education than re-education—a more difficult process—that is necessary. It is possible, however, more or less to re-educate the majority of patients who possess a fair degree of intelligence. Unfortunately, it is the person with an anxious, ambitious, over-conscientious, striving personality in whom the strain of overwork usually tells most strikingly. It is perhaps not so much the amount of work that harms him as the manner in which it is done; constant stress, worry, excitement, unhygienic habits of eating, poor and insufficient sleep, lack of relaxation and of vacations, and restriction of interests are among the commonest pernicious factors. The re-educator must endeavor to persuade such a person that experiments

have proved that more and better work can be done if a schedule containing fewer hours of work, more time set aside for brief periods of relaxation after meals, more frequent appointments for out-of-door recreation (say three or four times a week), and greater provisions for vacations be adopted.

For most people, hobbies are essential if they are to retain their health and their maximal capacity for work and for enjoyment. There is a wide range of avocations from which they may choose one or more suited to their special personal needs. Preferably the hobby should entail some activity quite different from the vocation that is the chief life interest. For the sedentary worker, dancing, or, better still, some out-of-door pleasure—a game, a sport, nature study or the like, should be enjoined. Active participation in a game is, of course, vastly preferable to the vicarious enjoyment that so many Americans are content with as spectators, say of baseball during the summer months, though the relaxation, the change of interest, and the hours in the fresh air obtained by the "baseball fan" are better than nothing. The rapid increase of interest in golf and the hold it has taken upon its devotees are indicative of its value as a form of exercise. Hitherto the expense attached to the game has limited its usefulness, but the provision of many new municipal courses is now making this valuable diversion available to ever more people each year. The time spent out-of-doors by participants in this game, the nature of the exercise itself, and its great intrinsic interest make golf one of the most serviceable sports, from the standpoint of health, to youth, to the middle-aged, and to people of advanced life, alike. Horseback riding and swimming are available for some, though not for all. Walking, however, is a form of exercise accessible to practically every one; it is particularly helpful if the excursion be made with a congenial companion, or if it be undertaken in association with some other out-of-door hobby, such as an interest in botany, in birds, in insects, or in geology. Gardening, with its variety of forms of physical

exertion, with the planning necessary for success, with its pleasures of anticipation as well as those of realization, makes a delightful hobby for those to whom it appeals; it may be possible to adopt gardening as a pastime even in a city if a small backyard be available. It goes without saying that whatever hobby or avocation is chosen should be one that the person enjoys or can learn to enjoy, though it may sometimes be necessary at first to cultivate the enjoyment. The disciples of Izaak Walton and the followers of Nimrod are often most enthusiastic over their pursuits; but fishing and hunting are, as a rule, of more value for the satisfactory utilization of longer vacations than in providing means for frequent out-of-door enjoyment and relaxation throughout the year.

For the worker whose regular vocation insures an adequate amount of physical exercise, there are available many quiet hobbies that are both intellectually interesting and emotionally enjoyable. Billiards, the game of bridge, and other card games, and various collecting hobbies may afford sufficient interest and enjoyment for some; but for others joy may be found and health favored through the study and practice of one of the fine arts (painting, sculpture, music), in the creation or appreciation of literature (poetry, history, biography, fiction, philosophy). The distinguished British statesman, Viscount Grey of Fallodon, has published a charming address on "Recreation" which he considers not only from the standpoint of health, but also from that of the "joy of life," which he thinks might be placed upon the same plane as the "duty of life." We recommend it heartily to the reader who has become conscious of remissness with regard to his recreative activities and who is seeking appropriately to change his manner of living.

Generally speaking, a tense active business man should take one long vacation of several weeks in summer and two shorter vacations at other seasons of the year. A salaried man or a factory employé may not be able to regulate at will his own hours of work or his vacation periods, but he can

always, if he will, cultivate some hobby and can ride it just as hard as anyone else, even though it must needs be an inexpensive one.

Finally, it should be emphasized that the cultivation of healthful mental attitudes is of very great importance for the health of the person. Tolerance, courtesy, equanimity, and a sense of humor that can extract some amusement even from misadventure are qualities that tend to counteract many of the deleterious influences of life. Here the parents of our rising youth should realize their great responsibilities, for in this connection by precept, and more important still by example, they can do much to make or mar the future happiness of their descendants.

PART THREE

SPECIAL DEGENERATIVE DISEASES

CHAPTER XIV

DEGENERATIVE DISEASES OF THE ARTERIES

Preliminary Notes on the Structure and Function of the Circulatory Apparatus.—The heart and the blood vessels (arteries, capillaries, and veins) form a closed system of chambers and tubes containing a certain amount of blood that is kept in constant circulation mainly by the muscular contractions of the heart. There are two more or less distinct circuits—(1) the pulmonary circulation and (2) the general or systemic circulation. In the former the blood is driven by force of the muscular contractions of the right side of the heart through the pulmonary arteries into the capillaries of the lungs, where the gaseous exchanges take place between the blood in the capillaries and the air in the lungs; thence the blood flows through the pulmonary veins into the left side of the heart. This pulmonary circulation is the shorter of the two circuits; the time required for the blood to flow through it is about one-fifth that necessary for the flow through the longer, systemic circulation. In the latter, the forceful contraction of the left side of the heart expels the blood into the aorta, thus starting it on its journey through the systemic circulation. From the aorta it is pressed into the next larger arteries, then into smaller and still smaller ones until the tiny, thin-walled capillaries of every organ and tissue all over the body are reached. From the capillary area the blood is collected by small veins, which empty into ever larger ones culminating in the inferior and superior venæ cavæ, which empty into the right side of the heart.

The time required for a particle of blood to make the complete trip through both circuits is estimated at about

twenty-three seconds, the exact length of the period depending upon the course followed (whether through the brain, the intestines, or the feet, for example) and upon certain physiological factors that determine the velocity of the blood-flow at the time. The aorta, which receives the blood from the left side of the heart, is much the largest and strongest of all the blood vessels; its branches are individually smaller, but in the aggregate they have a caliber larger than that of the aorta. The arteries divide into smaller and smaller branches much as a tree does; the total area of the branches greatly exceeds that of the primary trunk and the capillary bed, which corresponds to the finest twigs of the tree, is said to have an area 800 times that of the aorta. The capillary bed, then, is the broadest part of the blood stream, and, accordingly, the blood flows most slowly through it, the velocity being about 1-800 of that in the aorta. This passage through the capillaries is the most important portion of the circulation, for the main business of the circulation is done there; through the interchange between the blood of the capillaries and the tissues that surround them, provision is made for the chemical supplies for the nourishment of the tissues and for the removal of their waste products.

The circulation aside from the capillary area consists of an apparatus for maintaining the movement of blood; the heart is the pump, and the arteries and veins are the pipe-lines. The latter are not rigid, however, as are most pipes, but are elastic and also muscularly contractile. The aorta and the larger arteries, by virtue of their elasticity, store up some of the energy of the heart at each beat, and then, by their elastic recoil and by muscular contraction, pass the pressure on in the form of a wave called the "pulse." This pulse, the original source of which is in the heart-beat, persists to some extent even in the finest arteries, but it disappears when the stream enters the broad capillary bed where the blood flow is nearly steady, though there may be oscillation back and forth at certain moments. The flow of blood is fairly steady also in the veins, becoming somewhat more rapid, however,

the larger the individual veins and the smaller the total area through which the blood passes. The veins, then, are relatively passive tubes; but the arteries, through their elasticity and muscular contractility, are of importance for the production of active forces that help to maintain the circulation through the capillaries. Hence, whatever injures the elasticity or the contractility of the arteries diminishes *pari passu* the efficiency of the capillary circulation, unless, as usually happens, the heart can compensate for the defect by an increase in its work.

Since the arterial circulatory apparatus is not a rigid but a very elastic system, the pressure of the blood within it varies greatly in its different parts. Thus the pressure is very high within the cavities of the heart (during contraction) and in the aorta, becoming lower as the arterial bed broadens and as the individual arteries decrease in size, still lower in the capillaries, and lowest of all in the veins where the flow of blood, though rapid, is under very low pressure. Even between the beats of the heart a "minimal pressure" is constantly maintained within an artery by the tone of its elastic muscular walls and because of the peripheral resistance offered to the passage of the blood through the very small arteries and capillaries. With each heart-beat there is a marked increase in the pressure to a maximum known as the "systolic pressure." The minimal pressure is spoken of as the "diastolic pressure," and the difference between the diastolic and the systolic pressure is called the "pulse pressure." Only the "mean pressure" can be determined in the capillaries and veins.

Although the functions of the heart and of the vessels are in large part intrinsic and automatic, they are, nevertheless, constantly being regulated and controlled by the autonomic nervous system, and this control adds greatly to the efficiency of this really wonderful mechanism. We have stated in a preceding chapter that the blood pressure in any given artery varies many times during the day with the demands made by the body upon the circulation. In health these variations

are, of course, within what are considered "normal" limits. Everyone is familiar with the very rapid heart rate that occurs on vigorous exercise. This increased rate is necessary in order that the heart may pour out into the arteries a much greater amount of blood per minute than it does under conditions of rest. This increase in the rate and in the "minute output" of the heart would result in extremely high pressures within the arteries were it not for adjustments made by means of a controlling nervous mechanism; the latter is a balancing and compensating apparatus that simultaneously with the increased heart rate during exercise arranges for such a dilatation of the small peripheral arteries as will keep the arterial pressure relatively constant and at the same time will permit of an increase in the amount of blood flowing through special capillary areas—the prime object of the compensatory changes in the circulation. Correspondingly, when, for any reason, a constriction of the small arteries occurs, the blood pressure rises in the larger arteries, but this rise in turn is kept from becoming excessive by an almost simultaneous reflex slowing of the heart rate.

The chief function of the larger arteries (near the heart) is their elasticity; here structurally the walls of the arteries consist largely of yellow elastic tissue, there being but relatively little muscle tissue present. The main function of the smaller and more peripheral arteries lies, on the other hand, in their ability to undergo contraction (contractility), and the walls of the smaller arteries are composed mainly of smooth muscle fibers, which are controlled by the sympathetic or automatic nerve fibers. This musculo-elastic portion of the arterial wall is called the middle coat, or *tunica media.* Within this middle coat is an inner coat called the *tunica intima,* which is quite thin by comparison and is lined by a layer of endothelial cells that makes the inside of the artery very smooth. The outside coat or *tunica adventitia,* of the artery consists of a loose connective tissue and in it may be seen under the microscope both the tiny blood vessels that nourish the walls of the artery and the nerves that control

its muscle. The elasticity of the large arteries is such that if the aorta, for example, be removed from a cadaver and held in the two hands, it will after stretching promptly return again to its original length just as will a strong rubber band.

The muscular walls of the smaller arteries are maintained constantly in a state of partial contraction, called *tone*—one of the factors in the maintenance of normal arterial pressure. The amount of blood in the entire closed vascular system is adapted to this condition of tone of the smaller arteries and is not, as a rule, sufficient in amount to fill the entire system if all the arteries were relaxed. Sometimes, in a person with a sensitive nervous system, an emotional shock may cause the autonomic nerves to fail in their duty of maintaining the tone of the arteries. They then dilate; large volumes of blood pour into the dilated capillary areas in the dependent parts of the body, and, though the heart beats rapidly to compensate for the lack of tone of the peripheral arteries, the blood pressure falls, an insufficient amount of blood reaches the brain and the person *faints.* Usually if such a patient be placed in the recumbent posture the circulation becomes equalized, the arteries gradually regain their tone, and consciousness returns. Sometimes a similar change, though of much less degree, may occur when one suddenly rises from a recumbent to a sitting or standing posture. The tone of the vessels in the great intestinal area and in the legs may not be quickly enough adjusted to the change of position through which the column of blood is affected by gravity and the individual may have things "go black in front of his eyes" and experience a sensation of dizziness. The symptoms are usually only momentary and are more apt to occur in a patient who has been in bed for some time with an acute illness. When an opposite state occurs and the tone of the small arteries is disproportionately increased, the blood pressure rises within the arterial system and a diminished amount of blood enters the capillaries. It will be evident then that, although the heart-beat is the main source of energy in the circulation of blood, the arteries also play an

important active part in the proper maintenance of the blood flow.

The capillaries are exceedingly numerous, are very small, and have very thin walls. So numerous are they that one cannot stick a sharp needle through the skin without injuring some of them and permitting some of the blood to escape through the small puncture. Through the very delicate capillary walls chemical exchanges occur between the tissues outside and the blood within the capillaries. Thus the red blood cells give up their oxygen (obtained from the air in the lungs) to the tissue cells and fluids and receive from them the carbon dioxide and other waste products of tissue metabolism. The walls of the veins are thicker than those of the capillaries and they become ever thicker as the veins grow larger, though they are far from being as thick or strong as are the walls of the arteries.

Arteriosclerosis.—When the important and powerful musculo-elastic media of the aorta and larger arteries becomes frayed and thin from loss of elastic fibres, the intima within such weakened areas becoming thickened, degenerated, brittle, and incrusted with lime salts, and when the muscular media of the smaller arteries degenerates and is replaced in part by rigid deposits of lime, the intima of each vessel also undergoing thickening to such an extent that the caliber of the vessel is diminished, the formerly pliable, elastic, muscular, active arterial system is converted into a series of more or less rigid, passive tubes that can be of relatively little help in maintaining the steadiness of the capillary flow. Some of the small arteries may be entirely occluded and the tissue served by these arteries must necessarily suffer unless they can get their blood through other collateral channels. These are some of the changes that occur in *arteriosclerosis* or *sclerosis of the arteries.* The term "sclerosis" is borrowed from the Greek word meaning *hardness,* and is used also in describing somewhat similar changes that occur in other organs and tissues. The degenerated arteries lose their elasticity, are constantly being

stretched at each heart-beat without being able to return to their original shape, and hence become dilated, lengthened, and more tortuous. Such changes do not occur simultaneously throughout the entire arterial system, nor to the same degree in all parts of the body, even in advanced cases. It may be that only the aorta and the larger arteries are materially affected, in which event the chief functional loss will be in the elasticity of these great vessels and in their assistance in maintaining a satisfactory pulse wave. In extreme cases, there is danger also of a localized yielding in the vessel wall with the production of a saccular dilatation, or *aneurysm*, which, on account of the pressure within it and the thinness of its wall, is liable to rupture.

In another common type of arteriosclerosis, the changes occur chiefly in the smaller arteries. The muscular layer may be greatly thickened and kept continuously in contraction, or it may become weakened and the inner layer so tremendously thickened that the caliber of the vessel becomes so narrowed that the blood can scarcely pass through. In either event the function of the compensatory nervous mechanism is handicapped, the peripheral resistance to the blood flow is greatly increased, and the blood pressure remains constantly high with corresponding increase in "wear and tear" throughout the arterial tree. Changes like these handicap the circulation throughtout the body, but the symptoms and signs of the disease depend chiefly upon the particular organ in which the arterial changes are most pronounced.

The symptoms most commonly noted in arteriosclerosis are those arising from failing function of the heart muscle, of the kidneys, or of the brain. But there are some general symptoms associated with the widespread arteriosclerotic changes in the vessels, notably (1) indigestion, (2) a general "letting down" (both physical and mental), and (3) pallor, especially in the more advanced cases. It should be emphasized, however, that there may be fairly marked thickening of the peripheral arteries (the arteries at the wrists, those in the feet, and those in the temples) that may be easily felt

with the fingers, in the absence of any symptoms whatsoever. Arteriosclerosis may in some cases exist for years with no obvious impairment of health or of strength, though, in other cases, it may show very rapid progress and quickly become associated with troublesome and portentious symptoms.

As we have said, the organs are variously affected in different cases, and the early as well as the major symptoms depend upon the organ most involved in its structure and functions by the circulatory changes. One of the organs most frequently affected in the course of arteriosclerotic processes, is the heart. In all cases associated with increased blood pressure, the heart, in pumping the blood against the high tension in the aorta, is forced to work constantly under an increased load. Under this handicap the heart, because of the increased work that it performs, becomes larger and stronger, but this increase in size and strength occurs at the expense of its reserve power, which under normal conditions is one of the heart's most wonderful and valuable assets. As this reserve power becomes progressively diminished there may come a time when the heart can no longer respond to any suddenly increased demand and the patient is compelled to lead a very restricted life or to suffer from breathlessness, pain, dropsy, and other symptoms of heart failure (to be considered more fully in a later section). Heart failure in arteriosclerosis may be brought about (1) by the strain of working continuously against a high blood pressure, or (2) by reason of the impaired nutrition of its muscle consecutive to changes in the *coronary arteries* that nourish the heart, or (3) by a combination of the two factors above mentioned. An inadequate blood supply to the heart muscle leads to degenerative changes in that muscle; these, too, will be further considered in an appropriate section. One of the symptoms associated with arteriosclerosis of the vessels supplying the walls of the heart itself is *angina pectoris*. The victim of the distressing malady in which this symptom is liable to appear may be quite comfortable as long as

he remains quiet, but on extra exertion, especially if it closely follow a meal, he may experience a characteristic gripping feeling or constriction and a severe pain either in the left side of the chest or behind the breast bone and perhaps also a similar pain in the left arm. The pain may be extremely violent and is often associated with a fear of impending death. It is not surprising, therefore, that angina pectoris has become one of the most dreaded of heart diseases.

Symptoms referable to the kidneys occur in a large number of the cases of arteriosclerosis and especially in that type in which the changes involve particularly the smallest arteries and are accompanied by a high blood pressure. For a time there may be no marked symptoms, or if there be symptoms they are those often associated with high blood pressure (dizziness, headache, throbbing) without obvious evidence of kidney disease. Sooner or later, however, a change in the urinary output, especially an increase in the amount of urine passed at night, becomes evident. Examination of the urine may then reveal the presence of a little albumin and of a few microscopic casts of the kidney tubules. Further, it may be found that the kidneys do not now respond normally to the tests used to determine the degree of their functional capacity to rid the body of waste substances. A chemical examination of the blood may show at this time an abnormally large percentage of urea and of other substances containing nitrogen, an indication that they cannot be promptly excreted by the kidneys and therefore accumulate within the body; with continued degeneration and with ever decreasing functional efficiency of the kidneys, symptoms of "uremic poisoning" ultimately ensue.

The symptoms of hardening of the arteries of the brain are very important and very varied. The so-called "vascular lesions" account for a large proportion of all organic nervous diseases. As almost everyone knows, the different parts of the brain are specialized for different activities. Hence the symptoms of arterial disease in this organ will vary according to the portion of the brain most involved, as well

as according to the nature (acute or chronic) of the injury. Acute injuries may be caused by the rupture of an artery, with the pouring out of the blood (hemorrhage) into the tissues of the brain, or by the sudden closure of a vessel, cutting off the blood supply to a part of the brain, which then dies and ultimately becomes softer than the surrounding parts (softening of the brain). In either event, the onset of the symptoms is usually sudden, not to say fulminant, and the condition is spoken of as apoplexy or an apoplectic stroke. Obviously, many different nervous disturbances may be found after the patient has recovered from the immediate effects of the stroke, but as a matter of fact, a few of the small arteries of the brain are much more prone to rupture or to occlusion than others and the majority of the residues of apoplexy consist of paralysis, complete or partial, of one side of the body, that is, of the face, the arm, and the leg (hemiplegia).

In the degeneration of the small arteries of the brain there frequently occur little dilatations here and there along the course of the vessel. These dilated areas, called "miliary aneurysms," have very thin, defective walls, and under conditions of increased blood pressure, such as physical and emotional strain, the walls may give way. A sclerotic artery seems to be more prone to spasm—that is, to sudden contraction of the arterial walls—than is the normal artery. To such spasms of the vessels, with temporary shutting off of the blood supply, are attributed certain transitory nervous symptoms, resembling apoplexy, but which are followed by rapid and complete recovery, that are so common in cerebral arteriosclerosis. The patient may be unconscious for an hour or more, and paralysis of an arm, or of a leg, or of the whole side may last for a day or so. Sometimes the victim is unable to make use of words for a brief period of time (temporary aphasia).

Chronic symptoms of gradual degeneration of the brain (due to progressive interference with the blood supply) may also be quite varied. Among them are the common

mental symptoms of old age (loss of memory, of attention, and of concentration; insomnia at night, with drowsiness in the daytime; irritability; impaired judgment); ultimately, perhaps, a marked state of so-called "senile dementia" may develop. If the arterial degeneration involve the vessels at the base of the brain particularly, rather than those of the cortex, there may be marked motor symptoms, though without actual paralysis. All the voluntary muscles may become rigid and the movements performed clumsy. The person stands with head and shoulders stooped forward, the face shows very little expression, the arms are bent at a right angle, and the patient walks with little short steps. With these symptoms there may be coarse tremor of the hands, arms, head or of the whole body (*paralysis agitans; Parkinson's disease*).

Let us turn next to arteriosclerosis in the organs of the digestive system. There is an enormous capillary bed and hence great numbers of small arterioles in the intestinal area within the abdomen. This, of course, is for the purpose of absorbing the products of digestion and carrying them elsewhere in the body for utilization. Many of the students of arterial diseases believe that this so-called *splanchnic area* is the most important of all in that type of arteriosclerosis that is associated with high blood pressure and with changes in the smallest arterial branches. Though it is not uncommon to see cases of arteriosclerosis with "indigestion," a general term that may be used to indicate any gastric or intestinal symptoms, such symptoms are by no means so frequent nor so characteristic as might be supposed. Fortunately the arteries and veins serving the stomach and intestines have many intercommunications, or free "anastomoses," and this is probably the reason why there are not more constant and more characteristic abdominal symptoms in arteriosclerosis than are observed, for even if many of the smaller vessels were closed, those remaining open would be sufficient, in most cases, for affording the necessary blood supply. There are occasional

patients with hardened arteries who suffer from paroxysms of excruciating pain in the abdomen, very much like that felt in the chest in angina pectoris and relieved by similar measures. This is sometimes spoken of as "abdominal angina" and is thought to be due to spasm of the arteries within the splanchnic area.

Arterial disease of the extremities (arms and legs) affects, as a rule, the peripheral arteries of medium size, like those that can be felt in the wrist, in the arm, behind the ankle, and on the upper surface of the foot. Symptoms more commonly arise from arterial changes in the legs than from those in the arms. The disease may progress to the point where pulsation can no longer be felt in the arteries of the ankle and foot. There are cases in which the patient is comfortable as long as he is at rest, but after walking a little he experiences such pain in the legs that he must either limp or stop entirely. This condition is spoken of as "intermittent claudication," or "intermittent limping." In other cases, the capillary circulation is so much impaired at the end of the toes and foot that these distal portions begin to die (*gangrene*) and the part may have to be amputated. The gangrene that is not uncommon in chronic cases of diabetes mellitus is of arteriosclerotic origin. The healing of wounds or of ulcers on legs that are the seat of arteriosclerosis is often very slow and tedious.

The so-called "senile or decrescent type of arteriosclerosis," that is seen in aged people, usually affects chiefly the arteries of middle size. In these cases, the blood pressure is not characteristically elevated; indeed, it may be definitely below normal.

The Causes of Arteriosclerosis

In the preceding chapters we have emphasized the fact that in pathological processes, as a rule, and especially in chronic diseases, the effects produced in the body are the results of the interaction of a number of factors. In the following paragraphs we shall mention several conditions

that are believed to be of importance in bringing about "hardening of the arteries"; and although one or another—bad heredity, age, or a metabolic vice—may in an individual case stand out as the most prominent influence, yet it should be understood that even in that case probably two, three, or more conditions were operative in producing the disease.

Age.—Changes in the arteries are usual accompaniments of old age. It is common to hear a doctor say that "this man's arteries are hard, but no harder than one would expect at his age," or, on looking at an X-ray picture of the chest, that "the aorta is somewhat dilated, but not more than the age of the patient warrants." We have mentioned the tendency of the yellow elastic tissue to undergo atrophy as age advances and we have shown how important an element this tissue is in the structure of the arterial wall. When we think of the heart's incessant labor and of the frequent stress and strain to which the arteries are subjected, it is but little wonder that length of life seems often to depend chiefly upon how long the cardiovascular system can last.

Heredity.—In different people there are great differences in the length of time that it does last, and physicians have long been of the opinion that the quality of the "vital rubber," as the late Sir William Osler called it, is one of the important determining factors. Sometimes a man of forty may have arteries as hard as those ordinarily found in a man of sixty; in such a case the man's family history will sometimes reveal that his father, mother, or other ancestors were possessed of similarly poor tubing. We have in our files the clinical records of several brothers of one such family. The father of these patients died at sixty-five of pneumonia. He had been a man of great "driving power" and of nervous tension. Their mother died at sixty-four after suffering two apoplectic strokes incident to high blood pressure and arteriosclerosis. These parents had eleven children. Three of these had died at the ages of fifty, fifty-one, and fifty-two, of complications of arterio-

sclerosis; three others of forty-eight years of age and over already had manifested arterial hypertension. The remaining five members of this generation were below forty-seven years of age, and as far as was known none of them had as yet developed high blood pressure or shown any signs of changes in the arteries. One of them was, however, afflicted with diabetes and with nervousness, and another suffered from a kidney stone.

High Blood Pressure.—The normal blood pressure varies considerably during the day. It is relatively low during rest and sleep, and it is higher during periods of violent exertion. The systolic pressure in the artery of the arm may normally fluctuate from 110 to 170 millimeters of mercury under these varying conditions, and the diastolic (or minimal) pressure from 70 to 80 or 85. The average reading of a normal blood pressure in an ordinary interval of rest is about 125 for the systolic and about 70 for the diastolic. The efficient nervous regulating mechanism keeps it at a fairly uniform level.

We have already stated that in at least one type of high blood pressure (arterial hypertension) there are no demonstrable structural or organic lesions either in the arterial system or in other systems. This type has been called "hyperpiesis," or "essential hypertension," to distinguish it from those types of hypertension that are demonstrably associated with arteriosclerosis as a primary factor or with chronic kidney disease. This so-called essential type may occur in young adults or even occasionally in children, but it is most frequently encountered in persons between the ages of forty and sixty. It is presumably due to some factor or factors that bring about a constriction of the smallest arterial twigs (arterioles), so that the heart is forced to pump more vigorously in order to maintain an efficient circulation. That one of the factors producing the chronic arterial constriction is neural in character seems highly probable. For high blood pressure is more frequent in high-strung, restless, worrying people than in more phleg-

matic types; and we know, too, that nervous influences play a definite part in the fluctuations of normal pressures. Obesity, prolonged physical strain, the ingestion of an excess of food, overindulgence in tobacco or alcohol, lead poisoning, certain metabolic disturbances (notably at the time of the menopause or change of life)—all these may also, in certain predisposed individuals, aid apparently in causing an "essential hypertension."

Some of the cases run a very benign course with very little change from year to year; others, on the contrary, progress rapidly. The extra strain tells first, naturally enough, upon the arteries and upon the heart. The arteries are subjected to an extra stretching with each beat of the heart, and in addition to the usual wear and tear of life they suffer from this extra burden that they have to bear. Ultimately arteriosclerosis becomes well developed in the patients and is usually most marked in the small vessels. It has been shown experimentally, too, that by repeatedly injecting into animals substances that raise the blood pressure a sclerosis of the arteries can be induced.

Infection with Bacteria.—In people dead of typhoid fever, of pneumonia, and of some other infectious diseases, there may usually be found in the arteries small yellowish areas of degeneration due to the toxins of the disease. Whether, in those who recover, these areas heal entirely without scars is not definitely known, but many physicians who have studied the subject believe that these lesions lay the foundation for sclerotic changes that occur later on. The effects of prolonged absorption from chronic foci of infection in tonsils, sinuses, gums, jaws, and gallbladder must also be considered in this connection. Chronic tuberculosis is not infrequently associated with arteriosclerosis, although as a rule the blood pressure in this disease is low rather than high. Arteriosclerosis has been experimentally produced in animals by the injection of diphtheria toxin or of other bacterial products. Pathologists have described degenerative changes in the arteries of those dead of acute

rheumatic fever, the disease that causes disastrous lesions in the heart, and it may be that rheumatic fever in early life may be the starting point of an arteriosclerotic process.

Syphilis deserves a place by itself in the discussion of the causes of diseases of the arteries. It is one of the major enemies of the organs of the circulation; it may attack the heart, the larger vessels, or the smaller arteries. Strictly speaking, the lesions of syphilis are inflammatory in type, being due to the presence of the germ that causes the disease; this virus and the poisons it produces bring about destructive effects in the arteries and call forth an inflammatory reaction of the tissues. Degeneration is a term used ordinarily to denote a gradual deteriorative change in a tissue rather than acute changes associated with active infection; but acute degenerative changes in cells and tissues do sometimes occur. Syphilitic changes in the heart and blood vessels are so similar to those of chronic degenerative conditions in the same structures, and their effects are practically so nearly identical with them, that they deserve especial mention in this section. Though we emphasize the similarity of syphilitic disease of the arteries to arteriosclerotic processes, we would not confuse the two processes, which are entirely separate and distinct. They are considered together here merely for purpose of convenience.

One of the favorite localizations of the syphilitic process is in the aorta, the large artery that receives the blood directly from the heart. Syphilis often produces many tiny areas of inflammation and degeneration in the walls of this important vessel; they lead to a puckering and to great weakening of its walls.

Two important complications of syphilis of the aorta are prone to occur. If the syphilitic inflammation be located at the base of the aorta next to the heart, it may involve the aortic valves that prevent the regurgitation of blood from the aorta back into the heart during the period between beats. The puckering and deformity of these valves make them "insufficient" for the work of holding back the blood,

and the resulting valvular lesion is called "aortic insufficiency," or "aortic regurgitation"; it is one of the most serious of the valvular heart diseases. It may be noted here that a more purely degenerative arteriosclerotic process can also produce a similar valve defect. The second important complication of syphilis of the aorta is the production of *aortic aneurysm.* At some area where the wall of the aorta has been most weakened, there is a giving way of the wall, and then a gradual stretching and bulging of it with the pressure of the blood at each heart-beat. Thickened scar tissue about the aorta may prevent the escape of blood from the vessel, but it has not the elasticity or the strength to prevent the gradual enlargement of the aneurysmal sac. Such a bag of blood may become quite large, as large as an orange or a grape fruit, and may communicate with the aorta through a relatively narrow opening, the site of the original area of giving way of its wall. The aneurysm through the repeated pounding pressure of the pulse may erode the soft tissues and the bone and ultimately appear as a pulsating mass on the chest wall or it may point backward and compress important structures within the chest or the spine. Pain is often a distressing symptom of aortic aneurysm. The usual termination is by the rupture of the sac, with sudden death from hemorrhage.

Syphilis may attack also the smaller arteries. The results when the vessels of the brain are involved may be closely similar to those seen in arteriosclerosis of the same vessels. Apoplexy occurring in a young person is most frequently due to syphilis, whereas in an older person it is more usually due to arteriosclerotic changes.

Metabolic Poisons.—Several very important factors in the causation of arteriosclerosis in certain patients may be listed under this heading. It is often asserted that degeneration of the arteries is sometimes due to these endogenous poisonings; it would be safer to say that it is very frequently associated with them, although the mechanism by which the effect in the arteries is produced or the relation to the

endogenous intoxication may not always be precisely understood. In seeking for the primary causes of arteriosclerosis associated with vices of metabolism one must look farther back to the influences that have been responsible for the metabolic disturbance.

One of the most striking associations of the kind now to be considered is that of arteriosclerosis with diseases of the *kidneys,* particularly with diseases that involve the kidney tissues diffusely. During, or following, an acute infectious disease, especially scarlet fever, the kidneys may become acutely inflamed (acute Bright's disease); one of the symptoms of this disease is a slight, or moderate, rise in the blood pressure. The patient may recover entirely from such an acute condition, or the process in the kidneys may become chronic, in which event the kidney may gradually shrink in size and the blood pressure may become permanently raised to abnormal levels. In this chain of events arteriosclerosis is usually a sequel; it is probably referable in part to the effects of the high blood pressure and in part to the effects of the poisons retained in the body by reason of the functional incapacity of the kidneys.

Patients suffering for long periods from *diabetes mellitus* often develop a pronounced arteriosclerosis to which some of the so-called complications of diabetes are in turn due; thus the so-called "diabetic gangrene" of the feet is of arteriosclerotic origin.

Arterial degeneration occurs also in chronic *gout,* a disease in which very painful attacks of inflammation of the joints occur. This disease is associated with a disturbance in the metabolism of the purin substances; in it an abnormally large amount of uric acid is demonstrable in the blood. Fortunately, gout is relatively rare in this country; it does occur, but many of the cases diagnosed as gout are, in reality, cases of a lamentably common disease, infectious arthritis, or "rheumatism."

Of some importance also for the origin of arteriosclerosis are certain disorders of the glands of *internal secretion.*

Chronic thyroid diseases are especially prone to be associated with degenerative states, including those affecting the arteries. In exophthalmic goiter and in other toxic goiters the earliest and often the most conspicuous symptoms may be those referable to excitation of the cardiovascular system. When such thyreo-intoxication continues for years, degenerative processes occur especially in the heart muscle, but also in the arteries. High blood pressure is not infrequently found in patients with thyroid intoxication of long standing. Insufficiency of the thyroid secretion (as in myxedema) also predisposes to arterial degeneration, especially of the larger arteries. Experiments have been reported in which sheep regularly developed sclerotic changes in the aorta after removal of the thyroid gland.

The menopause, or "change of life," is a favorite time for the development of high blood pressure in women, and this fact suggests that disturbances of the ovarian secretion and perhaps also of the secretions of other glands may be the causal factors involved. That the arterial hypertension in such instances may be mediated by nervous influences (since marked nervous symptoms are often present at this time of life) is a conception that may reasonably be entertained.

Among the products of the several ductless glands there are certain substances, namely epinephrin from the suprarenal glands and pituitrin from the hypophysis cerebri, that when injected subcutaneously in appropriate doses cause a distinct rise in blood pressure. This fact has led some physicians to ascribe the origin of essential hypertension to an increase in the activity of the suprarenal glands and to suppose that in chronic disease of the kidneys or in arteriosclerosis of the smaller arteries the accompanying high blood pressure may be due to an excessive outpouring of epinephrin into the blood stream. Physiologists, however, maintain from their experiments that amounts of epinephrin sufficient to raise the blood pressure in this way are never given off from the suprarenals during life. There

are very delicate tests for this substance by which its presence may be recognized even in high dilution, and increased amounts have not been consistently found in the blood of patients suffering from arterial hypertension.

Obesity puts an extra strain upon the whole cardiovascular system, including, of course, the arteries, and is, therefore, a factor that should be considered in the causation of arteriosclerosis in some patients. Deficient activity of any one of several of the endocrine glands may be associated with the development of marked obesity. Thus obesity may occur in cases of lack of function of the thyroid, of the hypophysis (or pituitary) or of the sex glands (gonads).

Excessive and long-continued *muscular exertion* may also be a factor in the production of arteriosclerosis. Stevedores and other laborers whose work calls for continual muscular activity of the most strenuous sort appear to grow old "before their time." It has even been asserted that the vascular changes in these persons may be more marked in an arm that has been subjected to great physical strain than in the arm of the opposite side of the body. The effect of heavy muscular work upon arteries is shown also by the fact that it predisposes to the development of a syphilitic aortitis in patients who have been infected by the syphilitic virus. In statistics of syphilitic aortitis there is a definite preponderance of incidence in men over that in women, and aneurysm of the aorta is rather unusual in women, though relatively common in men.

Poisons from Without (Exogenous Poisons).—Chronic *lead* poisoning is notoriously prone to be associated with the development of arteriosclerotic changes, with consecutive degeneration of the kidneys and with cerebral hemorrhage. It has been confidently asserted (though also as vigorously denied) that chronic poisonings with *alcohol* and *tobacco* are important causes of hardening of the arteries. It must be admitted, we think, that definite proof is lacking for either side of this controversy. As we have already stated, when considering the effects of indulgence in either alcohol

or tobacco the element of the "personal equation" must not be lost sight of. Overindulgence in *coffee* and *tea* has been blamed by many as responsible for the origin of arteriosclerosis; here, too, the evidence is by no means convincing.

Errors of Diet.—Overeating, and especially the ingestion of an excessive amount of protein food, have for a long time been considered among the important factors in the origin of chronic arterial disease. In addition to the possible directly deleterious effects of the products of protein digestion and of the products of excessive intestinal putrefaction, there is also to be considered the element of obesity, which is prone to develop from overindulgence in the pleasures of the table. Undoubtedly, high blood pressure and arteriosclerosis are much more commonly met with among "free livers" than among the abstemious.

Prevention of Arteriosclerosis

The mere enumeration of the various possible causes of arteriosclerosis—age, heredity, high blood pressure with its various factors, infection with bacteria, metabolic poisons, poisons from without, overexertion and overeating—indicates the broadness of the field of prevention. It must be emphasized, too, that many of these causes may begin to operate early in life; hence it is advisable to inculcate proper dietetic-hygienic standards and practices in youth, and not to wait until middle or advanced life before thinking of means of prevention.

The "decrescent" type of arterial change that is really a part of the process of growing old may be considered to be inevitable. Owing to its late occurrence in life, to the type of arteries affected (those of large and of intermediate size), to the fact that it is as a rule not associated with high blood pressure, and to the infrequency of serious complications, this type of arteriosclerosis is of but little interest from the standpoint of prophylaxis. Of greatest interest are those types of arteriosclerosis that are of relatively

early onset (age forty to sixty) involve the smaller arteries, and are associated with the development of high blood pressure, for it is in these cases that the important complications on the part of the heart, kidneys, brain, and other tissues are prone to occur. In our time, the extensive use of instruments for measuring the blood pressure (sphygmomanometers) has demonstrated how very common a beginning or a well-developed arterial hypertension is, not only in people over forty, but also in people in the thirties. Whether in most of these persons the abnormal conditions have been due to bad tubing in the first place or to the "bad use of good tubing," we are not prepared as yet to say. A family history that leads one to suspect an hereditary basis is certainly common. It is also common to find situational factors and faults in early training that may be of equal or perhaps even of greater importance. When considering the influences of heredity, however, it should be borne in mind that not only may the determining factors for poor arteries be directly a part of one's inherited constitution, but one may inherit also factors that may be responsible for some of the predisposing conditions (obesity, diabetes, gout or thyroid disturbances). This does not mean that, in such circumstances of heredity, the patient is stoically to accept the fate of arteriosclerosis and high blood pressure as inevitable, and to relinquish the fight against them. Far from it! He should rather consider that his prophylactic campaign is more sharply defined than is that of the average person; indeed, he may be lucky to have discovered his handicap early. Acting upon the advice given by his physician, he may do much to ward off the dangers by which he is threatened.

Members of diabetic families should, for example, be instructed especially to avoid overnutrition, to eat very few sweets, to partake sparingly of starchy foods, to exercise particular care against the contraction of infectious diseases, and to keep the commonly exposed and easily infected parts of the body (nose, throat, mouth) in as healthy a condition

as possible. Those known to be predisposed by heredity to gout should be taught to eat sparingly, if at all, of foods rich in purin substances (sweetbreads, kidneys, liver, brain, beef extracts), to eat moderately of other foods, to lead as far as possible an open-air life with abundant exercise, to keep regular hours, and to abstain entirely from alcoholic beverages. Concerning the methods of preventing thyroid disturbance we have less accurate knowledge, though recent experiments indicate that the insurance of an adequate supply of iodin to the body is important. A few drops of Lugol's solution or of any salt of iodin given for several days at a time and repeated two or three times a year will probably suffice; or very small amounts of potassium iodid or sodium iodid may, if desired, be added to the ordinary salt used in the home.

The next step in the prophylaxis of degenerative states of the arteries due to these metabolic disorders lies obviously in the early recognition and proper treatment of those patients in whom symptoms of one or another metabolic disorder have developed. In the absence of known hereditary predisposition to metabolic disturbances, a most important field of prevention is that of the cases in which the first obvious manifestation of an existent or approaching arteriosclerotic disease is an increase of blood pressure. Despite our lack of a complete understanding as yet of the mechanisms underlying this condition, there is good reason to believe that the high-tension life of the modern business man (with his sense of competition, his continual anxieties, and his lack of exercise, relaxation, and recreation) is an important contributing factor. The degree of responsibility carried and the importance of the work a man does are not as significant, perhaps, as the way in which the work is done. It is the *tension* under which one lives and to which the nervous system is exposed that is most harmful. As we have already stated, the training of the nervous system to a life of regularity and of equanimity should be begun in the earliest years. Unfortunately, those with undesirable

hereditary factors with respect to "nervousness" are also those who are usually most exposed during childhood to unwholesome psychic contagion from parents. It is particularly desirable that parents of this sort should be taught the importance of the proper training of their children. Psychiatrists are advocating an examination of all school children by competent experts not only from the standpoint of intellect, but also from that of character and arrangements for thorough co-operation between the teaching in the home and in the school (Stewart Paton).

Aside from the preventive measures just referred to, we must in general rely upon the dietetic and hygienic doctrines outlined in previous chapters, laying special stress upon the dangers of overindulgence in food, alcohol, and tobacco, of becoming obese, of prolonged physical overstrain, and of bacterial infections. The importance of sufficient relaxation from work, of regular out-of-door exercise and of, systematically arranged vacations can scarcely be overemphasized as measures preventive of arteriosclerosis. Especially in cases of arterial hypertension, existent or threatened, such measures are often the most difficult of institution. Ambition, fear of shirking, self-sacrifice are motives that may be more powerful than those of fear of disease or desire for longevity. Many persons are so situated that their hours of work are fixed by others (their employers), and they feel that they cannot afford to risk the loss of their positions by insistence upon vacations. Fortunately, even selfish employers are gradually coming to see that the health of their employees is a matter deserving of special attention. Even when vacations are but few and short, there is no reason why one should not ride hobbies and also enjoy them both in anticipation and in retrospect.

Those who already manifest marked arterial hypertension should, of course, keep in close touch with a sensible family physician and seek his advice at regular intervals. Physicians think it wise in certain cases to advise (at regular intervals) a short period of rest in bed with a simple diet,

say a quart of milk a day and a little orange juice. The period necessary in one case might be one or two days in each month; in another case one day each week, or two-half days each week, may be required. A prolonged rest treatment (with complete mental and physical relaxation) away from home, with correction of various remediable defects, followed by a radical change in the habits of life, may be very beneficial in many cases, even in those of persons who have already suffered from distressing symptoms due to arteriosclerosis or to high blood pressure.

CHAPTER XV

DEGENERATIVE DISEASES OF THE HEART

The Structure and the Functions of the Heart.—The heart, the force pump of the circulation, lies within the chest, behind the lower portion of the breast bone, extending more into the left side of the chest than into the right. Its right border extends a little beyond the right border of the breast bone. In a person of average configuration the heart occupies a diagonal position, the apex or rounded end pointing downward and toward the left. In thin individuals with long chests, the heart occupies a position almost in the midline of the body, the apex pointing almost straight downward. In very obese people the heart is pushed up by the high diaphragm, because of the large amount of fat in the abdominal cavity, and so occupies a more nearly transverse position, the apex pointing toward the left. The heart is inclosed in a fibrous sac called the pericardium, within which there is also, normally, a small amount of clear fluid, which helps to serve as a cushion for the heart.

The heart itself is a hollow, muscular organ. Its cavity is divided longitudinally by a septum into two halves, the right and the left sides of the heart. The right side pumps blood into the pulmonary circulation and the left side into the general or systemic circulation. Since the systemic circulation is much the more extensive of the two and since the blood pressure in the aorta and its branches in much higher than that in the pulmonary arteries, the left side of the heart has more work to do than the right and is correspondingly heavier and stronger, its muscular walls being thicker. Each side of the heart is further subdivided into two portions, the receiving portion, or auricle, which collects the blood from

the veins, and the expelling portion, or ventricle, which forces the blood out of the heart into the arteries. There are thus four chambers of the heart: two thin-walled auricles, which receive the blood, and two thick-walled ventricles, which expel the blood. Between the auricle and the ventricle on each side a set of valves is so arranged that the blood may flow at the proper time from the auricle into the ventricle, but cannot flow backward from the ventricle to the auricle. Similarly, there are valves between the ventricles and the arteries to prevent the blood from coming back into the heart from the arteries. These thin valves, though purely mechanical features of the heart, are very important. Even more important, however, is the dynamic heart muscle, for it is the source of this organ's wonderful power.

The finer, microscopical structure of the heart muscle differs from that of muscle anywhere else in the body. It is unlike the ordinary voluntary skeletal muscles and differs also from the so-called smooth muscle contained in the blood vessels, in the intestinal tract, and in the uterus. It is unique, also, in its functions. We recognize at least four separate functions of the heart muscle—(1) that of stimulus-production, or the power of initiating a stimulus to contraction; (2) that of stimulus reception, or irritability, the power of responding to a stimulus; (3) that of conductivity, or the power of conducting the stimulus in an orderly sequence throughout the muscle bundles of the heart; and (4) that of contractility, the ability of the muscle fibers to shorten in length. In different diseased conditions of the heart muscle it is possible by modern methods of studying the heart to demonstrate abnormalities of each of these four functions. To a certain extent different parts of the muscular mass of the heart are differentiated for particular functions in that some portions of the heart muscle are more particularly adapted to one or another of these four capabilities. Thus, for example, there is a little node (near the entrance of the great veins into the auricles) in which the stimulus for the heart's action normally has

its origin. There is another somewhat similar node between the auricle and the ventricle, which also sometimes assumes this function. On the other hand, there is extending from the auricles down into the ventricles a bundle of muscle fibers which is especially differentiated for the function of conductivity and along which the impulse to the contraction wave is passed from auricle to ventricle. When this bundle (the bundle of His) is interrupted, very definite and characteristic changes occur in the action of the heart.

Let us follow for a moment the different events in one cycle of the heart's action. The two circulations, pulmonary and systemic, are carried on simultaneously. As we have said, the thin-walled auricles receive the blood from the veins, from which it is poured rapidly but under a low head of pressure. During the pause between two heart-beats the thick-walled ventricles relax, the pressure within the auricles becomes higher than that within the ventricles, the valves between them (the auriculo-ventricular valves) open and the blood pours rapidly from the auricles into the ventricles; then just at the end of this period the muscular walls of the auricles contract, forcing the last part of the blood from the auricles into the ventricles against the increasing pressure there. The contraction wave having now reached the ventricular walls, the ventricles begin to contract and the pressure within the ventricle begins to rise. The auriculo-ventricular walls, the ventricles begin to contract and the presauricles, and as the pressure within the ventricles continues to rise the valves between the ventricles and the aorta on the left side, and the pulmonary artery on the right side, open and the blood is forcibly expelled from the ventricles into those large vessels. At the end of the contraction of the ventricles their walls relax quickly, the pressure within the ventricles rapidly falls, and the valves between the arteries and the ventricles close, preventing the blood from flowing back from the arteries into the heart. Because of their shape, the delicate valves between the aorta and the left ventricle and between the pulmonary artery and the right

ventricle are called "semi-lunar valves." The valve between the left auricle and the left ventricle has two cusps and is called the bicuspid, or mitral valve; that between the right auricle and the right ventricle has three cusps and is, accordingly, called the tricuspid valve.

The functions of the heart muscle are largely intrinsic and automatic—that is to say, they are capable of going on if all outside connections, for example the nerves, are completely severed. The heart may even be removed entirely from the body and if perfused with a suitable fluid will continue to beat regularly for a time. But although it is automatic in the initiation of impulses to contraction and is to a certain extent sufficient unto itself, we have already seen in preceding chapters that it is constantly being regulated through the autonomic nervous system. Thus, there are certain nerve fibers stimulation of which tends to slow the rate of the heart, and there are other nerve fibers stimulation of which tends to increase the rate. Under normal quiet conditions the heart beats at the rate of from seventy to eighty times each minute; under excitement or increased work it beats at a considerably higher rate. Hour after hour, day after day, and year after year, this work of the heart goes on, with no rest except that obtained between beats. Under ordinary conditions we are quite unconscious that we have a heart in that we do not appreciate by our senses its activity. After exertion, such as running a race or climbing a steep hill, we feel the pounding of the heart in the chest; this feeling of pounding must in such circumstances be regarded as a normal sensation. But, under certain conditions, even while we are at rest, we may feel the heart pounding and surging within the chest; such a sensation or pounding cannot be regarded as a normal condition and the symptom is spoken of as "palpitation of the heart." Palpitation may be associated with structural disease of the heart, or it may indicate merely an abnormal nervous excitation of the heart. In the latter instance it need not, by

any means, indicate the existence of any serious pathological condition.

The heart is really wonderfully adapted for its primary purpose of maintaining constantly an adequate supply of blood to the capillaries all over the body. The need of the tissues for blood varies greatly under different conditions, but the heart is so constituted that it possesses a tremendous reserve power by means of which it is able to meet the demands for work made upon it even under extreme conditions. The difference in the amount of work done by the heart when the body and mind are at rest and that when the body is undergoing extreme physical exertion is very great. Some persons are, by nature, possessed of more capable hearts than are others, just as some people are endowed with a stronger, sturdier skeletal musculature than are others. By gradually increasing its activities it is possible to train the heart muscle to a capacity for great exertion; this, of course, is the main object of the training for athletic competition.

We have already repeatedly mentioned the effects of use and disuse upon the tissues and the organs of the body. The effects of increased activity and of decreased activity are particularly great upon the muscular tissues, including the musculature of the heart. When the heart has but little to do, its musculature becomes flabby. When it is given an unusual amount of work to do for a sufficiently long period of time, it becomes larger and stronger; hence in athletes the heart is hypertrophied—that is to say, its muscular walls have undergone thickening and strengthening and have become more capable of response to unusual exertion than those of the heart of the average person. When, by reason of mechanical defect in the heart itself or in the peripheral circulation, the flow of the blood stream becomes embarrassed, the function of the compensatory nervous mechanism is such that the heart responds by increased activity in order to overcome the handicap. In the ensuing adaptation there is often at first dilatation of the chambers of the heart, to be followed after a time by an increase in the thickness of

their walls, making more vigorous action of the heart possible.

Under abnormal conditions (in certain circulatory diseases) the heart may, even when the body is at rest, be compelled to do more work than the heart of a normal person does during active exercise. This means constant strain upon the heart, which may result in a very marked increase in its size through hypertrophy of its muscular walls and dilatation of its cavities. Although such a heart is really stronger and capable of doing more work than a normal heart, it must be distinctly understood that it is constantly engaged in heavier work than normal. Even when the body is at rest the heart in such circumstances may be doing as heavy work as it is capable of performing, so that it has but little or no force left in reserve to meet the demands for still greater work when the bodily activities are increased. Though by means of the increased power due to hypertrophy it has kept the circulation of the blood going despite handicaps, it has lost its reserve. Since it is working ever at maximal capacity, any increase of the physical activities of the patient will make demands upon the circulation that cannot adequately be met, and the patient will begin to suffer from symptoms of heart failure. The symptoms of heart failure are very much the same, regardless of the primary source of the circulatory handicap. Thus the primary disease may affect the valves, the heart muscle, or some structure entirely outside of the heart itself; but the symptoms of heart failure are due in the last analysis to insufficiency of the heart muscle; as long as the power of the heart muscle is adequate, the circulation may be very well maintained despite valvular or other defects.

Chronic Heart Disease

We have already mentioned that the heart is covered by a smooth membrane and that it is inclosed within a fibrous sac, which is lined by the same type of smooth membrane, the *pericardium*. The muscular walls of the heart are

spoken of as the *myocardium,* and the smooth inner lining of the heart that corresponds to the endothelium of the blood vessels is called the *endocardium.* Any one of these different structures, or all three simultaneously, may be diseased. When the disease is of an inflammatory nature, we speak of a *pericarditis,* a *myocarditis,* or an *endocarditis,* according to the particular structure involved.

To most people, perhaps, the term "heart disease" suggests at once a "leaky heart"—that is to say, a valvular defect. As a matter of fact, an uncomplicated valvular defect, permitting of a "leak," is the most benign type of heart affection. The most serious diseases of the heart are those that involve, directly or indirectly, the heart muscle itself. Many a person who has suffered an injury to a heart valve early in life has yet lived to old age without serious inconvenience from the defect. Unfortunately, however, most diseases that injure the valves injure the heart muscle also; upon the degree of the involvement of the latter depends very largely the outlook in any given case. The gravity of an affection of the heart is often very difficult to determine, because of the difficulty of estimating precisely the damage that the musculature of the heart has suffered.

Diseases of the Heart Valves.—The causes of valvular disease of the heart are of two general types—(1) infectious, (2) arteriosclerotic or degenerative. The two infections that are most frequently responsible for endocarditis (with its subsequent scarring and deformity of the valves) are (a) acute rheumatic fever and (b) syphilis. In pneumonia, gonorrhœa, septicemia, scarlet fever, smallpox, and some other infectious diseases acute endocarditis may sometimes occur. The portion of the endocardium that is most subject to stress and strain is that covering the line of closure of the valves. This, accordingly, is the region of the endocardial surface most frequently attacked by bacteria and their toxins. Since it is on the left side of the heart that the pressure is higher and the strain greater, it is upon

the valves of this side (the mitral valve and the aortic valve) that endocarditis is most frequently met with.

In the early stages of the acute form of endocarditis, there are tiny growths upon the surface of the valves called "vegetations." Sometimes, in very severe and unusual cases, ulceration and partial destruction of the valves also occur. Usually the deformities of the valves following an endocarditis are the results of an attempt on the part of the tissues to heal the lesion; there is a new growth of fibrous tissue and blood vessels and this ultimately undergoes contraction, as does any scar elsewhere in the body. It is this contraction that causes the puckering and deformity of the valves. Through such chronic inflammation the valves may become thickened and the cusps fused together. The valvular orifice may, in this way, become narrowed, a condition spoken of as "stenosis" of the valve; in the case of the mitral valve (between the left auricle and the left ventricle) it is called "mitral stenosis," whereas in the case of the aortic valve (between the left ventricle and the aorta) it is called "aortic stenosis." Instead of a narrowing of the orifice, there may result an "insufficiency" of the valve; the valve can no longer close the orifice and thus permits the blood to pass backward in the wrong direction. Mitral insufficiency (or mitral regurgitation) and aortic insufficiency (or aortic regurgitation) are terms used to indicate the existence of such valvular insufficiencies. Often at a valvular orifice both a stenosis and an insufficiency may exist at the same time; each of these conditions of the valvular orifices is of course a handicap to the hearts' action. In "stenosis," the blood passes through the narrowed channel over a longer time and with greater difficulty than normal. In "insufficiency" the blood passes first in the proper direction, but later returns in part to the chamber from which it was expelled; hence the heart must obviously do extra work in order to compensate for this regurgitation.

Acute rheumatic fever, chorea, and heart disease form a triad of diseases which physicians have long known may

be associated with one another. Very frequently these three conditions are accompanied, or preceded, by tonsillitis. Rheumatic fever may sometimes exist without chorea and chorea sometimes without rheumatic fever; and occasionally the manifestations on the part of the heart are observed without an accompanying rheumatic fever or chorea, or at least without their being obvious. In some cases the joint disturbance of the rheumatic fever is so mild that it is not remembered by the patient. In a well-developed case of rheumatic fever the patient is very ill; in addition to the fever, sweating, and other constitutional disturbances manifested, one after another of the joints may become swollen, red, painful, and exquisitely tender to touch. It is rather characteristic of the disease that as other joints become involved those earlier affected clear up. The disease usually lasts for several weeks; even after apparently complete recovery, it may recur, at intervals, many times. The disease is particularly common in young people. It has been estimated that about half the cases of rheumatic fever are complicated by disease of the heart, though it is difficult to determine the exact percentage of cases in which cardiac complications occur, for though at the time of the acute illness no signs of heart trouble may be evident, these signs may develop years later. The rheumatic virus may attack not only the valves of the heart, but also the heart muscle and the pericardium as well. Any of the heart valves may be affected in rheumatic fever, but those on the left side (either the mitral or the aortic valve or both of them at the same time) are more often involved than those on the right.

When syphilis affects the heart valves it usually attacks, as we have already seen, the aortic valve, since this valve lesion occurs as an extension of a syphilic inflammation of the aorta just above the valve. Syphilitic aortitis with aortic valvular disease occurs usually between the ages of twenty-five and forty; indeed, most cases of aortic valve disease originating during this period are due to syphilitic

infection. Aortic valve disease before the age of twenty or twenty-five is, on the contrary, usually due to rheumatic endocarditis.

Aortic insufficiency is usually regarded as a more serious condition than mitral disease, probably because of the fact that the orifices of the coronary arteries (the arteries that nourish the heart muscle) lie just above the aortic valves and are often involved when they are diseased. And involvement of the coronary arteries sooner or later causes lesions in the heart muscle itself.

Arteriosclerosis in the aorta may extend to the aortic valves; it may lead either to aortic insufficiency or, by causing a fusion of the cusps, to aortic stenosis. A somewhat similar degenerative process may occur in the mitral valves, but it is less common and is, moreover, a less serious lesion.

Diseases of the Heart Muscle

Causes.—Diseases of the muscle of the heart may be due to (1) infection with bacteria, (2) arteriosclerosis, (3) fatty infiltration, (4) toxic factors from either without the body or within it (for example, from overindulgence in alcohol, tobacco, coffee, and tea, or from the poisons of goiter). Functional disturbances of the heart muscle may be caused by still other influences, such as abnormal nervous excitation and overexertion.

Among the infectious diseases, rheumatic fever and syphilis occupy the first places in the causation of diseases of the heart muscle, as they do in that of valvular diseases. As we have already hinted, acute rheumatic fever is almost as much a disease of the heart as it is a disease of the joints; in this disease any portions of the heart—the pericardium, the myocardium, or the endocardium—may be affected. In most of the cases in which the endocardium of the valves is diseased, the heart muscle also suffers. Although the acute phase of rheumatic fever is usually met with in the first half of life, the subsequent degenerative changes in the heart may persist for many years before heart failure, due

to them, sets in; death in the later portion of the life span is not infrequently due to a heart failure that had its remote origin in rheumatic fever of early life.

Syphilitic disease of the myocardium may be localized in one or in a few places in the heart muscle, or it may affect the whole structure of the heart muscle diffusely. One important way in which syphilis may lead to disease of the heart muscle is through involvement of the orifices of the coronary arteries in syphilitic aortitis, leading to narrowing of these vessels and consequent interference with the blood supply to the heart muscle. Another important syphilitic lesion of the heart is that sometimes met with in or near the conducting bundle between the auricles and the ventricles ("bundle of His"). This lesion may block the impulses passing from auricle to ventricle, so that these two portions of the heart may be compelled to beat independently of each other. The condition thus arising is spoken of as "heart block"; when it exists the pulse is much slower than usual, due to the fact that when the ventricles beat independently of the auricles their rate is slower. The existence of heart block does not necessarily prove that a syphilitic affection has occurred earlier, for though syphilis is a common cause of heart block, it is by no means the only cause of that condition which may occur in the entire absence of syphilis.

Other infectious processes of some importance in the causation of chronic disease of the heart muscle are typhoid fever, scarlet fever, smallpox, septicemia, influenza, and focal infections in the tonsils, about the teeth, or at other sites in the body.

Arteriosclerosis is an important factor in the causation of many cases of disease of the muscle of the heart. Changes may be produced in the heart muscle by reason of the hardening of the coronary arteries. There may be gradual narrowing of these arteries resulting in an insufficient supply of blood to the heart muscle, as a result of which a slow degeneration sets in, with formation of small patches of fibrous tissue; or there may be a sudden blocking of the channel

of a large coronary artery, resulting in the sudden death of a large portion of the heart muscle supplied by that vessel. In the latter case sudden death not infrequently occurs; indeed, this is one of the common causes of sudden death. Should the patient survive such an attack, the effect upon the heart will depend somewhat upon the size and location of the lesion in the heart muscle; the portion of the heart wall involved will of course be greatly weakened, and this weakness may lead to subsequent rupture of the heart or to the formation of an aneurysm of the heart, a rather rare condition that is analagous to the aneurysm of the aorta already described. Aside from injury to the heart muscle through coronary sclerosis, arteriosclerosis may damage the heart muscle in other less direct ways. Thus in sclerosis of the small arteries (arterioles), associated with high blood pressure, increased work is thrown upon the heart muscle, which undergoes hypertrophy. Poisons may accumulate in the blood, owing to arteriosclerotic changes in the kidneys, and these poisons may further damage the heart muscle. Patients with high blood pressure not infrequently die from ultimate failure of the heart muscle.

Fatty changes in the heart are of two general types—(1) so-called fatty degeneration of the heart-muscle fibers and (2) fatty infiltration between the muscle bundles. The first form occurs in severe infectious diseases, in marked anæmias, and in various other poisonings. Symptoms due to such fatty changes are apt to be masked by those of the general disease process. From the standpoint of prevention of chronic heart disease, the fatty infiltration of the heart that occurs in obese people is more important. There is a certain amount of fatty tissue in the pericardium of normally nourished individuals, for the pericardium is one of the natural fat storehouses of the body. In obese people, however, the amount of fat stored in the pericardium may become enormous; and it may even extend down into the heart substance between its muscle bundles and actually replace some of the muscle tissue. A great embarrassment of the

heart's action results, an embarrassment which, moreover, is added to that already existent by reason of the heavy weight of the body that must be carried and of the extra tissue that must be nourished.

That toxic substances such as tobacco and the poisons of toxic goiters may, in susceptible persons, materially influence the function of the heart muscle is now generally conceded. It is also believed by many physicians that these and other similar agents can bring about actual structural changes in the heart muscle, somewhat similar to those produced by infection and by arteriosclerotic processes. The terms "tobacco heart" and "goiter heart" have long been familiar in medical literature, as well as in the parlance of the layman.

There have been reported a considerable number of cases in which the heart has been enlarged (hypertrophied) and in which heart failure has been seen relatively early, but in which no cause has ever been determined. The heart muscle has been found hypertrophied and the cavities of the heart dilated without other changes in the structure of the heart muscle, or of the heart valves, or of the circulatory organs elsewhere in the body. Such cases are sometimes spoken of as examples of "idiopathic hypertrophy of the heart." They are, as yet, but poorly understood.

Irregularities of the heart-beat are of great interest and have been the subject of a great deal of study, especially during the past ten years. These irregularities may be due to a disturbance of any one of several functions of the heart muscle—irritability, contractility, and conductivity.

The so-called *sinus arrhythmia,* or *respiratory arrhythmia,* is due to nervous influences acting upon the "pace-maker" of the heart, the node near the juncture of the veins with the auricles where the stimulus for the heart-beat originates. This type of arrhythmia is seen in a great many people and is practically a normal phenomenon in youth. On deep inspiration, the heart rate is slowed and on expiration it is somewhat increased in rapidity.

The so-called *extrasystole,* or extra beat, occurring at irregular intervals is often perceptible to the patient and may, especially when first experienced, excite in him a great deal of alarm. This type of irregularity is due to a heightened irritability of the heart muscle and the inauguration of a stimulus in a portion of the heart muscle in which it does not normally occur. The consequence is an extra beat, followed by a longer pause than usual, which may make it seem to the person affected as though his heart had stopped beating. Sometimes the patient describes his sensations to the physician by saying that it seemed as though the heart had "flopped over," or had "turned over," or that the heart had "seemed to cease beating" and "then a very strong beat occurred."

This extrasystolic irregularity may occur quite infrequently, say once or twice a day or at even longer intervals; or it may occur so nearly continuously that it may be difficult to distinguish it from other forms of continuous irregularity. It is not uncommon in smokers, and in those who use coffee to excess. It is not uncommon also in association with mildly toxic goiters.

Extrasystolic irregularities may recur at intervals for a great many years without any other evidence of effect upon the heart muscle. It should be remembered, however, that extra systoles may also occur in association with definite structural disease of the heart muscle.

Although they are at times a source of great annoyance to the patient, extrasystoles may occur sometimes in large numbers and very frequently without being at all perceived by the person himself. Such extra or premature beats may originate in various parts of the heart muscle; those originating in the auricles are called "auricular extrasystoles," whereas those originating in the ventricles are known as "ventricular extrasystoles."

In the condition spoken of as *paroxysmal tachycardia* there is a very rapid heart-rate, which occurs in paroxysms. The disturbance is somewhat akin to that in which extra-

systoles or premature contractions (just mentioned) occur, in that it is due to abnormalities of the initiation of the heart's impulse. An attack is characterized (1) by a rapid rate, (2) a pulse that is usually regular, and (3) by a sudden onset and a sudden termination. A paroxysm may be short, occupying the time of only a few heart-beats, or it may continue from a few minutes to a few hours or longer, sometimes persisting even for days. A feeling of palpitation, or a vague sense of discomfort in the chest is often associated with the attack and a feeling of marked relief is experienced when the paroxysm has passed. Such attacks occur most frequently in persons suffering from organic heart disease, but they may occur in those in whom there is no other evidence of existence of disease of the heart.

Another important type of irregularity of the heart is called "auricular fibrillation." Many muscle fibers or groups of fibers of the auricles contract in an apparently chaotic and irregular rather than in a co-ordinated manner; it is as though there were a general quivering of the mass of muscle rather than an orderly contraction wave. Some of the impulses to contraction pass through the conducting fibers to the ventricles, but they pass so very irregularly that the ventricles also contract in a totally irregular manner, both the rhythm and the force of the ventricular beats being greatly altered. The rate of the left ventricle and therefore of the arterial pulse is usually rapid, between one and two hundred per minute. With such a rapid rate, many of the ventricular beats are of insufficient strength to affect the pressure of blood within the cavity, so that with the feeble beats no blood is forced into the aorta and, accordingly, no pulse corresponding to the feeble beats can be felt in the arteries. The rate as determined by listening over the heart will be greater, therefore, than that determined by feeling the pulse, and there is then said to be a "pulse deficit."

The mechanism of "auricular fibrillation" is still some-

what a matter of conjecture, one theory laying most stress upon an abnormality of stimulus production and another upon abnormality of stimulus conduction. Recently, a so-called "circus movement" explanation has been favorably considered, but for a discussion of the nature of this we must refer the reader to special texts. Two important points about this irregularity are (1) that it occurs usually in hearts that have already been structurally damaged and (2) that when it has once appeared it usually persists. There are, however, cases in which it occurs in paroxysms of only a few hours' or a few days' duration.

Untreated, "auricular fibrillation" is a distinct handicap to the circulation. The minute output of the heart may be distinctly lessened by it. Under proper treatment with digitalis some of the impulses passing from the auricles to the ventricles may be blocked and the ventricular rate in this way slowed down to from seventy to ninety beats per minute. These beats are then sufficiently strong to maintain the circulation quite satisfactorily, even though the auricles continue to quiver. Within recent years still other forms of medication (especially with quinidine) have been used with some success in stopping the fibrillation of the auricles and in restoring the normal rhythm. This method of treatment should be attempted, however, only under most careful observation, for it sometimes precipitates certain circulatory accidents (embolism) that are not devoid of danger.

Still another important cardiac irregularity is that produced by a blocking of the stimulus wave or of the contraction wave at some portion of its course. Such a block may occur practically anywhere in the heart, but the most important site is in the "His bundle" that connects the auricles with the ventricles. The disturbance of the heartbeat thus caused is spoken of as "heart block." Though often due to pronounced structural changes in the heart muscle, it may sometimes be brought about by toxic influences (for example, by the drug digitalis or by the poisons

of infectious diseases) and also by powerful stimulation of the vagus nerve. When the block between the auricles and the ventricles is complete, the ventricles are no longer stimulated to contract by impulses that arrive from the auricles, but initiate their own contraction impulses and thus beat with their own specific rhythm the rate of which is much slower than that of the auricles. A very slow pulse (twenty to forty beats per minute) is therefore characteristic of heart block. Sometimes, especially at the onset of heart block, attacks of dizziness or of fainting, due to temporary anæmia of the brain, occur; this clinical picture constitutes the so-called Stokes-Adams syndrome.

Finally, we would mention a disturbance of the heart beat in which powerful and feeble beats alternate with one another, giving rise to a pulse at the wrist in which every other beat is feeble (*pulsus alternans*). This disturbance of the function of contractility always indicates a severe impairment of the integrity of the heart muscle, and is of grave omen.

The irregularities of the heart-beat have been extensively studied during the past few years, but even yet they are not thoroughly understood. Some of them are benign and occur in otherwise apparently normal hearts; others are of serious significance. Often those that are most obvious and most annoying to the patient may be of the least gravity, whereas disturbances of which the patient may be entirely unconscious may be really menacing.

Pain in Heart Disease.—Pain is by no means a necessary or even a frequent accompaniment of heart disease, but in certain diseases of the heart it is a striking feature.

The terrible pain of angina pectoris has already been mentioned in connection with arteriosclerosis of the coronary arteries, which nourish the heart muscle. Other types of pain may also arise, or seem to arise, from the heart.

Physicians have attempted to distinguish two general types of cardiac pain, those due to disturbances of cardiac function and those due to structural changes in the heart.

Young people of nervous constitution sometimes complain of a dull "ache" in the left side of the chest that may perhaps be felt also in the left arm; this "ache" may be associated with other symptoms such as palpitation, general weakness, bluish discoloration of the hands, and coldness of the hands and feet. Cases of this sort are not uncommon under the ordinary conditions of life, but they were met with particularly frequently in the armies during the World War. In England they were spoken of as cases of "disordered action of the heart" and in America usually as "neurocirculatory asthenia" or "effort syndrome." The malady is of nervous origin and is referable to a disturbance of the nervous mechanism of the heart and of the arteries. No demonstrable structural change in the organs of the circulation need be present.

Among young nervous people there occur instances in which severe pain simulating that of real angina pectoris is experienced; the symptom has been spoken of as "pseudo-angina," but its significance is quite different from that of the pain in angina pectoris vera.

True angina pectoris, which occurs usually in people past middle age, is definitely associated with structural changes in the heart, usually with partial occlusion of the coronary arteries due to disease of their orifices at the root of the aorta. It may, however, be difficult or impossible for the physician on clinical examination of the patient to demonstrate objectively any abnormality of the heart, and between attacks of the atrocious pain the circulation may seem to be perfect.

Compensation and Decompensation of Heart Lesions; Circulatory Failure.—The heart may be structurally diseased with respect to its valves, its muscle, its pericardial covering, its supplying arteries, or even all its component portions simultaneously and still the circulation may be very well maintained. The changes in the heart are then said to be perfectly "compensated" for. Extra work done by the heart muscle counterbalances the defects under which

it works. With relatively slight defects of the structures of the heart, a satisfactory compensation may be maintained throughout a long life. With more serious defects, however, the strain ultimately becomes too great for the heart muscle; the compensation is lost, and "heart failure" ensues —or, to use a better term, "circulatory failure." By circulatory failure we mean a condition in which the blood circulates so slowly that the tissues fail to receive the proper supply of oxygen and food and to be relieved sufficiently promptly of their waste products. Defining it in another way, we may say that heart failure occurs when the ventricles can no longer expel as much blood as the auricles try to pour into them. The blood becomes dammed back upon the organs and tissues (lungs, liver, gastrointestinal tract, kidneys, extremities), the veins and the capillaries become dilated, and the flow through them becomes sluggish.

The symptoms of circulatory failure are numerous and the first symptoms to appear may differ considerably in different cases. Usually, shortness of breath on slight exertion is one of the striking early symptoms. From a series of careful clinical histories Pratt has tabulated the initial symptoms in 100 cases of heart failure as follows: shortness of breath in 60; pain in 19; pressure beneath the breast bone in 8; palpitation in 4; swelling of the feet in 3; rapid heart rate in 3; cough in 1; œdema of the lungs in 1; unconsciousness in 1.

The breathlessness is usually first noticed on exertion, but ultimately, in extreme cases, it may become so marked that even when the patient is entirely at rest in bed shortness of breath is experienced and the patient must be propped up on pillows in order to be able to breathe at all comfortably. Sometimes in so-called "cardiac asthma" there are paroxysms of shortness of breath during the night, which may last for several minutes and may be mistaken for ordinary bronchial asthma. Although different cases of heart failure may present certain individual features,

nevertheless the essential symptoms of heart failure are the same regardless of the original cause of the condition. In well-developed cases we always observe the same shortness of breath, evidences of congestion of the lungs and of the abdominal organs, cough, indigestion, scanty urine, swelling of the legs and of the dependent portions of the body, and effusion of fluid into the cavities of the chest and the abdomen.

The causes of circulatory failure include (1) disease of the heart itself, whether of the heart muscle or of the heart valves or, as frequently happens, of both together; (2) diseases of the pericardium that have resulted in the formation of extensive scar tissue and of adhesions uniting the heart, the pericardial sac, and the surrounding tissues, especially the chest wall; (3) chronic changes in the peripheral circulation, including, in the systemic circulation, chronic arterial hypertension (due to arteriocapillary disease, to chronic Bright's disease, or to other cause) and, in the pulmonary circuit (of relatively less importance), those met with in emphysema, chronic bronchitis, or extensive fibrosis of the lungs; and (4) acute changes in the peripheral circulation (for example, vasomotor paralysis in pneumonia and in other infectious diseases).

The onset of circulatory failure does not necessarily mean imminent death. As a rule, patients recover from the first attack. In chronic circulatory diseases, there may be one, two, three, or more periods of circulatory failure from which, with proper treatment, the patient recovers. The length of interval and the comfort experienced by the patient between attacks depend upon the severity of the primary defect and upon the patient's activities in the interim. With proper care, cases with circulatory defects may experience long periods of comfort and usefulness. Each case of circulatory disease should be carefully studied for itself and the patient advised by his physician, with particular reference to his special individual needs. There are dangers in too little activity as well as in excesses of

performance. There is also a lamentable possibility that a given patient may "lie down under his handicap" and drift unnecessarily into a life of chronic invalidism. Thus, some children with relatively insignificant heart lesions are kept by their parents "in cotton wool" and are brought up with the idea that they must lead lives of absolute dependence. A proper amount of carefully graded exercise and some carefully controlled work are nearly always helpful to cardiac patients. Just what amount is proper must be especially determined for each individual case by the supervising physician.

The strains that bring about failure of the circulation when the heart is diseased are of different sorts; in other words, there are many different "precipitating" or "exciting" causes of circulatory failure. Thus, in one person, a sudden or a prolonged physical stress or strain may be responsible; in another, emotional distress may be the causative factor. Reinfection superimposed upon an earlier disease of the heart valves or of the heart muscle, toxemia in an acute infection (like pneumonia), inadequate sleep and rest, and states of poor general nutrition may be important factors. Hence a patient suffering from heart disease or from a circulatory handicap of any sort should learn how much he can do with safety, should obey strictly certain rules of hygiene in his daily habits of work, rest and sleep, should eat small, easily digestible meals, should avoid the use of alcohol and tobacco, and should exercise especial care against contracting infections.

The Prevention and Relief of Chronic Heart Disease.—More people die from chronic heart disease than from tuberculosis or from pneumonia, and about twice as many as from cancer. It is estimated that some 2 per cent of the general population (about 2,000,000 people in the United States) have chronic heart lesions, and that more than 150,000 deaths annually are due to this cause. After a statistical survey the following statements have been made by Louis I. Dublin:

"Under twenty-five years of age, organic heart disease causes as many deaths as typhoid fever;

"Between twenty-five and thirty-four years, organic heart disease causes as many deaths as lobar pneumonia;

"Between thirty-five and forty-four years, organic heart disease causes more deaths than Bright's disease;

"After forty-five years, organic heart disease shows a higher death rate than any other cause."

Since many, if not all, cardiac patients pass through periods of invalidism and non-productivity, there is a tremendous economic loss in addition to the human suffering and the loss of life entailed. Deaths from tuberculosis and from pneumonia have been decreasing for a number of years, whereas the reported deaths from chronic heart disease have been increasing. Some of this increase has been due, undoubtedly, to better diagnosis and to differences in the registration of the causes of death; but some of the reported increase corresponds to a real increase in incidence, probably referable to an increase in cases of chronic arterial hypertension under the too keenly competitive stress and strain of our modern life.

Until recently neither physicians nor members of the laity have been in the habit of thinking of chronic heart disease as preventable. But the steady growth of interest in preventive medicine in general, the striking successes of prophylactic measures against typhoid fever, diphtheria, and some other infections, the marked decrease in the death rate from tuberculosis, and the increased realization of the importance of infectious diseases for the causation of chronic heart disease, have gradually brought about a change of attitude. During the past ten years there have been established in a number of the larger cities in this country special clinics, convalescent homes, schools, and societies for the care of patients with chronic heart disease and for the prevention of these diseases. The Association for the Prevention and Relief of Heart Disease of New York City, the pioneer in this movement, has rendered most valuable service in

the co-ordination of the work of physicians, social workers, nurses, and teachers in outlining problems to be solved, in devising methods of procedure, and in classifying cases. The classification adopted by this association is as follows:

ORGANIC HEART DISEASE

Class 1. Patients who are able to carry on their full habitual activity.

Class 2. Patients able to carry on diminished physical activity.
a. Slightly decreased.
b. Greatly decreased.

Class 3. Patients who are able to carry on no physical activity.

POSSIBLE HEART DISEASE

Class 4. Patients who have abnormal physical signs in the heart, but in whom the general picture or the character of the physical signs leads one to believe that they do not originate from cardiac disease.

POTENTIAL HEART DISEASE

Class 5. Patients who do not have any suggestion of heart disease, but are suffering from an infectious condition that may be accompanied by such disease—*e.g.*, rheumatic fever, tonsillitis, chorea, or syphilis.

In connection with this association there are (1) special clinics for heart diseases in the many hospitals and dispensaries of the city, (2) night classes for cardiac patients who are at work during the day, (3) convalescent homes where patients are received after recovery from circulatory failure or after the recognition of a heart lesion, (4) employment bureaus by which patients are placed in positions appropriate to the gravity of their defect, (5) special schools for children with heart disease under the public-school system, and (6) the office of the central association that attempts to co-ordinate the activities of the various branches and to promote an interest in the prevention of heart disease among physicians and laymen.

In the classification given above, it is, of course, the

potential cardiac patients of Class 5 that are the chief interest of those working for the prevention of heart disease. The infections that are of particular importance in the causation of heart lesions are, as a rule, those of childhood or of early adult life. The most important of these are (1) acute rheumatic fever (with its frequent associates, chorea, or St. Vitus's dance, and tonsillitis) and (2) syphilis. Less important infections from the standpoint of the prevention of heart disease are scarlet fever, diphtheria, typhoid fever, measles, and whooping cough. Unfortunately, we are ignorant as yet of the exact cause of acute rheumatic fever, but we know a number of important facts regarding it. Thus, for example, we know that an important gateway by which the virus of this infection gains entrance into the body is tonsillar or adenoid tissue; or an infected tooth may be a portal of entry for this virus. We know, further, that a patient who has once had an attack of rheumatic fever is subject to recurrences of the infection and that at each recurrence there is increased liability to cardiac damage. It has been variously estimated that from one-third to one-half or more of all those who contract rheumatic fever suffer damage to the heart; and, as we have already seen, this damage may be to the heart muscle, to the heart valves, to the pericardium, or to all three portions of the heart. Patients who give a history of having had an attack of rheumatic fever must therefore be considered "potential heart cases." Most frequently the heart lesion develops while the subject is still manifesting fever and other acute symptoms of the rheumatic malady, but in some cases, and especially for the development of mitral stenosis, the heart disease may not become apparent for some time, even years, after the original rheumatic infection.

We may attempt to prevent rheumatic fever (and, through it, heart disease) by systematic examinations of children both in the pre-school age and in the age of school attendance, by the prompt treatment and, when necessary, the removal of infected tonsils, adenoids, and teeth, and by care in the

maintenance of good nutrition and hygienic surroundings. After a person has suffered an attack of rheumatic fever every effort should be made to prevent a recurrence of the malady. The tonsils, the pharynx, and the teeth should be examined with special care, and when diseased areas are discovered they should be treated or removed. Dietetic and hygienic regimens should be outlined with great care in order to maintain the nutrition and the general health at the highest possible level.

One point should be especially emphasized as important for the prevention of heart disease, and that is the desirability of a longer period than usual of rest in bed during convalescence from any acute infection. Indeed, it should be a rule for all patients after an acute infectious disease to prolong, rather than unduly to shorten, the period of rest in bed during convalescence. Most of us have a vivid recollection of the influenza epidemic and of the lamentable results experienced by those who attempted to resist its prostrating influence too long, or who too early arose from their beds after the infection had subsided. Physicians are very familiar, too, with patients who, despite severe respiratory infections (sinusitis, tonsillitis, bronchitis) with fever and other general symptoms, refuse to stop work, even when requested to do so by their medical advisors. The risks that they run of sustaining material damage to various structures of their bodies, including the heart, are substantial.

Practical obstacles to reform in the direction mentioned exist. Among these are (1) inadequate hospital facilities for prolonging convalescence, (2) ignorance of patients of the danger that they run, and (3) lack of interest on the part of some physicians in insisting upon preventive measures. With regard to rheumatic fever, however, physicians are united in recommending a period of rest in bed for the patient after all acute signs of the malady have subsided and of a still longer period of rest in case of indication that the heart has been in any way damaged.

The prevention of syphilis is a special subject into which

we cannot here enter. The campaign of the association for social hygiene is doubtless of some efficacy in educating people to the dangers of exposure to infection. The prompt and vigorous treatment of each case as soon as possible after recognition of the existence of syphilitic infection is of course a logical procedure. Unfortunately, it seems probable that the localization of the disease in the heart and in the arteries may occur relatively early in the course of the disease.

A large and important group of persons in whom heart failure sooner or later occurs is the contingent of those who for years have had high blood pressure in association with arteriosclerosis or with renal disease. The important features of the campaign for the prevention of arterial hypertension have already been discussed, and the prevention of chronic diseases of the kidneys will be dealt with in a later section.

The care of patients in whom heart lesions have already developed or in whom the signs of chronic arterial hypertension or of chronic renal disease have already appeared may also be considered a part of the work of preventing heart disease for in the special care of such patients we are endeavoring to prevent, or at least to postpone, the circulatory failure that is so likely sooner or later to complicate the clinical picture in such cases. Some patients with chronic heart disease or with chronic arterial hypertension will acquire some restraining influence that will help them to avoid overexertion and that will discourage overambition, whereas others will need encouragement to as great a degree of activity as is compatible with their welfare in order that they may avoid an unnecessary degree of chronic invalidism. Obviously opportunities for special education in the best methods of living under handicapped conditions should be available to all cardiac patients. Family physicians here have an important work to do, as have also specially organized heart classes, heart clinics, and convalescent homes or farms for cardiac patients such as have already been established in

several places in this country. Cardiac patients will learn from such agencies not only to pay more attention to the ordinary rules of hygiene than do their less handicapped fellows, but also to give heed to certain special rules suitable to their particular needs.

The schooling of a child that has a disease of the heart should not be interrupted, where it is possible for it to be continued with safety. In some of the schools special arrangements have been made for children with heart disease whereby they have their own entrances and exits that permit of the use of elevators or at least of the avoidance of hurry in climbing stairs. The amount of exercise suitable to each child is arranged for, but, as a rule, children with heart lesions are not permitted to engage in competitive exercises. Satisfactory nutrition should of course be maintained by means of good wholesome food, but overloading of the stomach should be avoided and any tendency to obesity should be early counteracted.

All patients, young or old, with heart lesions should get plenty of rest at night. They should spend at least nine hours in bed each night and should rest, lying down, for at least a brief period in the early afternoon. Sudden physical exertion, such as that involved in cranking a motor car, in running up stairs, or in lifting and carrying heavy objects, should be avoided. In the pursuit of any activity, the cardiac patient should remember to stop before he becomes exhausted. He should never permit himself to become unduly tired; a state of weariness from which he does not quickly recover on rest is an indication that permissible limits have been exceeded. Golfing, horseback riding, gardening, walking, motoring, croquet, and other mild sports in moderation are preferable to the more strenuous exertions of swimming, tennis, or baseball.

The heart patient should realize the importance of avoiding "catching cold." He should for this reason avoid unusual exposure, especially getting wet or chilled, and he should exercise some prudence in keeping at a distance, as

far as practicable, from those suffering from colds or other acute infections. Avoidance of the potential dangers of retaining in the body focal infections in situations from which they may easily and safely be eradicated must be emphasized for the cardiac patient; we refer especially to infected teeth, infected tonsils, and infected sinuses. A brief period of general anæsthesia for operation is usually well borne by patients with heart lesions, provided any heart lesion present is compensated at the time.

Small, easily digestible meals eaten at regular intervals are advisable for cardiac patients. If, for the purpose of improving the general nutrition, it be considered desirable for a cardiac patient to eat more than a moderate amount, it is better that he take five small meals a day rather than three large ones.

As to the other habits, the bowels should be carefully regulated, so that both constipation and diarrhœa are avoided. The use of alcohol and tobacco should be entirely interdicted.

The cardiac patient should understand thoroughly that breathlessness, pain in the region of the heart, slight swelling of the ankles, distress behind the breast bone, or palpitation, may be a signal that his heart has not a sufficient margin of reserve force. On observing such a signal, he should at once seek competent medical advice, for it may become necessary promptly to make a decided change in the routine of his daily life. Any one of the symptoms mentioned should be taken as a warning that the reserve force of his heart is being too much drawn upon, and he should act as promptly with regard to the matter as he would if his bank had sent him a notice of overdrawal of funds.

A very important matter for the cardiac patient is the occupation that he continuously follows. Physicians know very well that entirely too often patients come into the hospital suffering from failure of the circulation and recover after a few weeks, only to go back to an old occupation that involves activity decidedly beyond their powers of endur-

ance. One of the very important functions of the social workers in connection with heart clinics is the placing of their patients in occupational situations that do not make too great demands upon the reserve of their hearts. In many industries there are paid positions that do not entail great physical exertion and which permit the worker to remain seated almost all of the time. Classes in vocational training in which handicapped persons may be educated to work that is within their powers are other useful adjuncts to heart clinics.

Finally, it need scarcely be repeated that mental and physical relaxation, diversion, hobbies, and vacations are even more important for the heart patient than for the average person. Necessary and desirable as these are for healthy people, neglect of them by cardiac patients is attended by more than ordinary danger. Associations for the prevention and relief of heart disease can do much to make available for the impecunious restorative methods that at present are scarcely accessible except to the well-to-do.

CHAPTER XVI

THE CHRONIC DEGENERATIVE DISEASES OF THE KIDNEYS

Structure and Function of the Kidneys.—The kidneys, through the secretion of urine, rid the body of a certain amount of water and of waste substances. Among these waste substances are (1) those that contain nitrogen (for example, urea, uric acid, creatinin, and ammonia) derived from the metabolism of proteins and purins and (2) various inorganic salts, notably sodium chlorid (common salt).

The kidneys thus eliminate from the body practically all of the end products of protein and purin metabolism and also almost all of the mineral salts. By selective excretion through the urine of acid substances the kidneys help also to maintain the normal slight alkalinity of the blood and of the body tissues.

Although the urine consists largely of water, it is not the only medium by which water leaves the body. The lungs get rid of about one pint of fluid each day and from one pint (under quiet conditions) to possibly several quarts (under vigorous exercise) are passed out through the skin in the form of perspiration. The daily amount of urine varies considerably. For this a number of different factors (the amount of fluid ingested; the amount of fluid lost through other channels, say by perspiration, diarrhœa, vomiting; sometimes diseased conditions of the kidneys themselves) are responsible. The average daily amount of urine passed by a healthy adult person is about one quart or one quart and a half.

There are two kidneys, one on each side, situated just in front of the two lowest ribs and the strong muscles that hold

the back erect. They hence lie just behind the abdominal cavity, through which they may sometimes be felt. They are, as a rule, embedded in a mass of fat and have a fibrous capsule, which envelops them closely. The two kidneys are of approximately equal size, each measuring about four inches in length by two inches in width by one inch in thickness. The urine from each kidney enters a little pouch called the pelvis of the kidney, whence it passes down a fairly long channel called the ureter to the bladder, that is situated at the lowest portion of the abdominal cavity, where it serves as a reservoir for the urine. From the bladder the urine may be expelled more or less at will through a shorter channel (the urethra) to the exterior. There are, then, two kidneys and two ureters, but only one bladder and one urethra. At the base of the bladder and just behind the posterior portion of the urethra in man is situated the prostate gland, a part of the male sexual apparatus.

If one make a sharp cut through a kidney and look at the cut surface in a good light he may sometimes see in the outer or cortical portion many fine dots that are just visible to the naked eye. Under the microscope each of these dots will be seen to be a tuft of blood capillaries surrounded by a capsule or envelope. This structure is called a glomerulus. The envelope around the glomerulus is lined by a single layer of epithelial cells and is called Bowman's capsule. The cavity of this capsule is continuous with that of a long and very much convoluted tube or tubule that is lined by a single layer of epithelial cells that vary in character in different parts of the course of the tubule. Through this long convoluted tubule the urine, which begins in the Bowman's capsule, must pass on its way to the pelvis of the kidney. The glomerulus with its Bowman's capsule and the long tubule leading from it constitutes the structural unit of urine formation. It is estimated that each human kidney contains about 2,000,000 such units and that the 4,000,000, units contained in the two kidneys if placed end to end would extend for a distance of seventy-five miles. If

this calculation be correct and each unit secretes the same amount of urine, the amount of urine formed by each unit would be only about 8 or 10 cc. in the whole lifetime of seventy years. The structural units are bound together by the undifferentiated connective tissue in which may be found numerous blood vessels and nerves. The kidney is even more intimately dependent upon a good blood supply than are most of the other organs of the body. It has been shown experimentally that the kidneys consume more oxygen than the average tissues of the body, and that when active they consume over 10 per cent of the oxygen taken up by the whole body. The formation of urine is very largely dependent upon the pressure within the kidney arteries and capillaries and upon the rapidity of the blood flow through them. Hence changes in the circulatory system are quickly reflected in the kidneys and consequently in the amount and character of the urine excreted.

The exact method of formation of the urine has never been satisfactorily demonstrated. It is now generally accepted, however, that the glomeruli act as filters, holding back in the blood the solid portions like the cells, as well as certain albuminous materials dissolved in the fluid portions, but permitting some of the water and the crystalloid substances to pass out of the blood through the capillary membranes into the space within Bowman's capsule, which is continuous with the urinary tubule. As the fluid filtrate passes down the tubule, its chemical constitution undergoes change either through secretion of other substances into it by the cells that line the tubules or by the absorption from it of certain substances by these same cells. It is possible that both processes (secretion and absorption) may occur at different portions of the renal tubule.

From what has just been said of the structure of the kidneys it will be easily appreciated that here again we have to deal with a very large capacity for function in reserve over and above that which is needed for ordinary life. Indeed, one whole kidney may be removed (an operation not

infrequently performed because of certain unilateral disease) and the remaining kidney, if healthy, will perform the necessary work of urinary excretion for the body quite satisfactorily. One can, further, easily understand that many of the small structural units above mentioned might be destroyed by chronic degenerative processes and yet so long as a sufficient number remain in a healthy condition the urine formation may be continued satisfactorily and no symptoms of renal insufficiency develop. This explains why a person may have a chronic kidney disease for years without the development of any marked symptoms. There may be, and usually are, some changes in the quantity and in the quality of the urine that can be recognized by the application of special diagnostic methods. Changes may occur also in the blood pressure and in the size of the heart, before the patient himself becomes aware of anything abnormal. Such troubles cannot, of course, be detected early unless medical examinations are made at more or less regular intervals.

When an excessive amount of urine is passed the symptom is spoken of as polyuria. When only a small amount is passed we speak of oliguria, and when no urine at all is passed of anuria. Complete anuria may persist for fourteen or even for nineteen days, and yet the patient may recover. In the early days of kidney surgery in a few unfortunate cases the only serviceable kidney was removed by the surgeon and it was found that a kidneyless patient might live for as long as eleven days. Surgeons, nowadays, before removing a diseased kidney always make sure of the functional efficiency of the kidney that is to be left behind.

Chronic Degenerative Diseases of the Kidney.—Inflammation in the kidneys due to bacterial infections or to injuries brought about in other ways are spoken of as *nephritis,* from the Greek word, *nephros,* meaning kidney, and *itis,* referring to inflammation. They are also referred to frequently as "Bright's disease," because Richard Bright was the English physician who first satisfactorily described them and associated the symptoms with changes in the kidneys.

Chronic degenerative changes in the kidneys may originate in any one of three different ways: (1) as a sequel of acute nephritis; (2) as a result of arterial changes; (3) as a result of the back pressure of the urine from obstruction to the urinary outflow (in the ureters, the bladder, or the urethra).

Acute Nephritis.—Acute inflammation of the kidneys may result from the poison of any one of the infectious diseases. It is particularly frequently associated with scarlet fever. Just as acute rheumatic fever often produces an inflammation of the heart, so scarlet fever often causes an acute inflammation in the kidneys. Acute nephritis is less common as a complication of typhoid fever, measles, diphtheria, smallpox and other acute infections. It may occur with acute tonsilitis or in association with other so-called focal infections.

Certain chemical poisons (such as mercury, arsenic, turpentine, cantharides, potassium chlorate, and carbolic acid) may damage the kidneys to such an extent that an acute general inflammation results. Sometimes poisonous products are formed during pregnancy and damage the kidneys. All such poisonous substances reach the kidneys through the blood stream and hence tend to involve the whole kidney substance diffusely.

In many cases of acute nephritis, after a period of illness of several weeks' duration, there is apparently complete recovery. In some cases, however, the symptoms persist to some extent; instead of returning to normal, the kidneys become the sites of a chronic degenerative process through which the secretory units gradually disappear and are replaced by fibrous connective tissue, which through scar formation deforms the kidneys with production of the small contracted granular organs that are characteristic of chronic renal disease. The pathological process in the kidneys varies somewhat in different cases, but it would only be confusing to the general reader to describe the variations that occur.

Arteriosclerosis and Renal Disease.—The opinion is growing among physicians that many of the cases formerly thought to be primarily of renal origin are really primarily arterial diseases with secondary changes in the kidneys. People who manifest high blood pressure and have suffered changes in their smallest arterioles will almost always sooner or later suffer from chronic degenerative changes in the kidneys. Just as chronic arterial hypertension (with its arteriosclerosis of the smaller arteries) accounts for a large proportion of the cases of heart failure after middle life, so this same arterial disease is associated with many of the chronic degenerative changes in the kidneys common at this period of life.

Obstruction to the Outflow of Urine.—Obstruction to the outflow of urine may occur in one of the ureters, in which case, of course, only one of the kidneys will be involved. If this obstruction be complete, the kidney on the side affected will undergo complete atrophy and all the work of excretion of urine will be thrown upon the other kidney, which, however, will usually perform this work satisfactorily. More serious types of obstruction (since they involve both kidneys equally) occur at the mouth of the bladder or at the posterior portion of the urethra.

Obstruction in the ureters may be due to the formation of stones in the pelvis of the kidney. These stones may become impacted in the ureter, where they produce a complete obstruction of that channel. Closure of a ureter may be brought about in other ways (by inflammation with the production of strictures, or by pressure of a tumor from without).

Obstruction in the urethra (or lower outer channel) may be caused by strictures incident to the scar formation following acute infections, particularly gonorrhœal infections. One of the most important factors in obstruction of the lower urinary tract, however, is the enlargement of the prostate gland that takes place in many men in the sixth and seventh decades of life. When the central portion of this gland is

the one chiefly involved, the enlargement may press forward into the base of the bladder and against the posterior portion of the urethra in such a way that the bladder cannot be completely emptied of urine. In such cases after the patient voids as much urine as he can, there is still always left a certain amount in the bladder that is called "residual urine." As the enlargement of the prostate continues this residual urine increases in amount until it may be impossible for the patient to void any urine at all. Before the residual urine has reached such amounts there will have been a marked damming back of the urine upon the ureters and upon the kidneys. The ureters and the pelves of the kidneys through this pressure become dilated, and the secretion of urine by the kidneys becomes greatly hampered. Such patients, if allowed to go untreated, will sooner or later die from kidney failure or, as it is called "uremic poisoning."

In some organic diseases of the spinal cord, a paralysis of the bladder may occur with inability on the part of the patient to void urine naturally; in them, too, one may observe the accumulation of a large amount of residual urine. In such cases, also, the damming back of the urine will, in time, produce chronic degenerative changes in the kidneys that may end in uremic poisoning.

Symptoms of Chronic Kidney Disease.—As has already been stated, chronic disease of the kidneys may exist for a long time with no symptoms whatever noticeable by the patient. If he be examined, however, in these earlier stages a trace of albumin and a few casts of the urinary tubules may be found in the urine and the blood pressure may be slightly elevated. Later on the patient may pass a gradually increased amount of urine and may show a tendency to void ever more urine at night, necessitating arising at night two or three times for this purpose. Still later, the patient may complain of lassitude, of difficulty in sleeping, of disordered digestion, of headache, of failing vision, or of breathlessness on exertion.

Insufficiency of the kidneys with retention of urinary

poisons in the blood (uremia) is manifested chiefly by symptoms on the part of the nervous system. These symptoms may be diverse, though the commoner ones are headache, shortness of breath, disturbances of vision, vomiting, diarrhœa, transitory paralyses, convulsions, and loss of consciousness.

Prevention of Chronic Kidney Disease.—The problem here is divisible into three main tasks: (1) that of preventing the acute infections that are likely to be followed by chronic degeneration of the kidneys, (2) that of the prevention of chronic arterial hypertension and of arteriosclerosis (already discussed), and (3) that of the early relief of any form of urinary obstruction.

In earlier sections of this book we have indicated the great advances that have been made in the prevention of infectious diseases through general public health measures, and we have referred to some of the special methods by which our resistance to certain of these diseases may be raised. Against the infectious disease that is perhaps of the greatest importance in childhood as far as the kidneys are concerned, namely, scarlet fever, we have at present no specific methods of prevention, though through the application of the general public health measures of isolation and quarantine much of value can be accomplished. Very active research work, however, is being conducted at present along the lines of preventive measures against scarlet fever. Attempts to discover methods somewhat analogous to those now available for the prevention of diphtheria seem promising; it is greatly to be hoped that these efforts will be successful. When scarlet fever occurs, something may be done through treatment of the patient to prevent damage to his kidneys. Thus no matter how mild the infection may be, the patient should be confined to bed from the very onset and he should be kept in bed for at least ten days after the fever has entirely subsided. The diet during the illness should consist chiefly of bland foods (milk, gruels, fruit juices) and the patient should be encouraged to drink large amounts of water in

the hope that the toxins may pass through the kidneys in such dilution that the harm done may be minimal. We can scarcely overemphasize the importance of prolonging the period of rest and of protection from chilling of the body surface during convalescence from the disease, for it is at this time that symptoms of nephritis are especially prone to appear. This same provision applies with almost equal force to the management of all acute infections, as we have already emphasized when discussing the prevention of heart lesions.

The eradication of chronic foci of infection in the tonsils, in the paranasal sinuses, and about the teeth and gums is doubtless of importance, too, for the prevention of chronic degenerative changes in the kidneys.

Measures for the prevention of chronic arterial hypertension and of chronic arterial diseases have already been discussed; we refer to them again here because of their importance also for the prevention of the secondary disease of the kidneys to which they often give rise.

The most important of the urinary obstructions, from the standpoint of the prevention of secondary renal injuries, are those that occur at the base of the bladder or in the posterior urethra. Strictures of the urethra are usually sequels of venereal disease, especially of gonorrhœa, and a consideration of their prevention brings up the large problem of the prophylaxis of venereal infections in general. Prompt and efficient treatment of the acute inflammation of the urethra in gonorrhœa will do a great deal toward the prevention of the chronic strictures that often follow insufficiently treated cases. Even after such strictures have formed they may be satisfactorily treated, though by different methods.

The operative treatment of simple enlargement of the prostate or, as it is called, benign prostatic hypertrophy, so common in men over fifty years of age, has been wonderfully improved within the past two decades. Formerly, the operation for removal of the prostate was followed by a very high mortality probability, but since urological surgeons have

paid especial attention to the kidneys before operation and have employed methods for the gradual reduction of the back pressure of the urine until the functions of the kidneys have improved, the mortality following prostatectomy (as well as that following removal of a portion of the prostate) has been so greatly reduced that the operation is now considered to be a relatively safe surgical procedure. Unfortunately, some patients put off the operation until the kidneys have become so badly damaged that the operative risk is decidedly great; the chances of a satisfactory recovery of kidney function are far less when operation is thus ill-advisedly delayed.

Concerning the prevention of urinary obstruction in chronic organic diseases of the nervous system that cause anæsthesia of the urinary bladder or paralysis of its walls, a word should be said. Skillful urological attention may do a great deal toward relieving the pressure in the urinary passages in such cases and toward preventing the infections of the bladder and the ureters, so prone to develop in such conditions. The far more important matter of the prevention of the nervous diseases that can be the cause of such urinary obstruction will be discussed in a later chapter.

Hygienic Hints for Patients Suffering from Chronic Diseases of the Kidneys.—Longevity will of course be greatly favored by the early discovery of the existence of chronic degenerative changes in the kidneys. The discovery of such conditions is, at the present time, most often made by life-insurance examiners. As the custom of having regular yearly medical examinations made for the purpose of keeping well rather than for the cure of illness grows, we may expect still earlier recognition of a tendency to renal disease. Years ago the late Sir William Osler read to a medical society a paper entitled "On the Advantages of a Trace of Albumin and a Few Tube Casts in the Urine of Men Over Fifty Years of Age." [1] Though the presence of albumin and of a few casts in the urine at this age may not be of very

[1] *New York Medical Journal*, 1901, lxxiv, 949–950.

serious significance, still it is an indication that the body should be thoroughly studied and that a change should be made in the habits of life. In many instances, as Doctor Osler said, the discovery may be of positive advantage, for through it a man may be made to realize, perhaps for the first time, that he has been living somewhat carelessly and imprudently. In general in such a case, the indications are to live in such a way as to throw the least possible strain upon the heart, the arteries, and the kidneys. One should take careful stock of his methods of living and modify them here and there where modification is needed. Sometimes it will be found that the hours of work should be curtailed, that more time should be spent in physical exercise, or that better arrangements should be made for mental relaxation and for regular vacations. The methods of living that we have advocated for patients with chronic arterial hypertension are equally applicable here. In general, a quiet life with mental worry reduced to a minimum, with mild out-of-door exercise, and avoidance, as far as possible, of the extremes of hot and cold weather, are advantageous. A diet should be maintained that will not throw excessive work on the kidneys; for this reason it should be kept low in proteins and in salt. The intake of salt (sodium chlorid) should not exceed the body's requirements; the salt intake should be reduced to the lowest amount compatible with a reasonably palatable diet. In its general caloric value the diet should be just sufficient to maintain the body's nutrition. If the patient be overweight a definite reducing regimen should be started at once and an effort made to bring the weight to a figure closely approximating the calculated ideal weight. There is no single diet that dare be recommended for every patient; the physician should outline it in each case according to the individual requirements. We may emphasize, however, that a low protein diet means only one small portion of meat, chicken, or fish once per day, and not more than one egg per day. There is no support, from scientific data, for the popular view that white meat and fish have any advantage

over ordinary red meats, except in so far as they are of lighter weight and are, perhaps, more easily digestible. Eight or ten glasses of water may be taken each day, but alcohol should be strictly interdicted. Coffee or tea once a day is permissible.

Violent physical exertion and excessive mental application should be avoided. The high-strung, active, restless worrier should cultivate the study of a stoical or an Oriental philosophy and should endeavor to put into practice some of their preachments.

Elimination by the bowel is particularly important for the patient with chronic disease of the kidneys, and great care should be taken to maintain this function efficiently. As a rule, if there have been constipation, it is best to attempt to secure satisfactory evacuations by regulation of the diet and by means of mechanical measures rather than by the habitual use of active laxatives. The physician, however, must decide in each case when it is wise to make use of purgatives. An occasional saline laxative in the morning may be very useful in some cases.

Daily tepid or warm baths, especially if followed by a brisk rub, aid in keeping the skin in good condition and thus promote its excretory functions.

A patient suffering from disease of the kidneys should exercise great care to avoid infections, and if one be contracted, say an ordinary cold in the head, he should remain in bed for several days on a simpler diet than usual. Such a patient does well also to visit a good dentist at regular intervals with special reference to the possibility of infection about the roots of the teeth or of pyorrhea, and he should consult his physician early if there be any indication of the presence of a focus of infection elsewhere in the body. Slight recurrent infections and intoxications of the kidneys are common in chronic degenerative states of that organ, especially in patients who harbor focal infection elsewhere in the body.

CHAPTER XVII

DEGENERATIVE DISEASES OF THE DIGESTIVE APPARATUS

Structure and Functions of the Liver and Its Appendages.—The liver is the largest glandular organ in the body, weighing as a rule about 1,600 grams, or 3 pounds, in a person of average size. It is situated in the upper portion of the abdominal cavity immediately beneath the diaphragm. Much the larger part of the organ is on the right side, the smaller, left lobe, extending across the midline on the left side. The upper portion of the dome of the liver lies behind the right fifth rib and the lower edge of it reaches the lower border of the ribs.

The liver is tremendously vascular—that is to say, it contains a great many blood channels that are capable of holding an amount of blood equal in weight to about one third of that of the liver itself. This organ is peculiar in that it has two different sources of blood supply. One supply is that of the hepatic artery, a part of the general systemic circulation; this supply is similar to that of the other organs and tissues. But, in addition to this supply, the liver has also the so-called portal circulation. Through it, all of the venous blood from the stomach, the intestines, and the spleen passes through the liver. The arterial blood, reaching the stomach, the intestines, and the spleen, passes through the capillaries of these organs where the foodstuffs are absorbed; this blood is then collected into tiny venules, which open into larger veins and finally empty into the large portal vein, which enters the liver, where it again breaks up into many finer branches and ultimately into capillaries

through which the blood comes into intimate contact with the cells of the liver.

The *functional unit of the liver* is called a liver lobule, each lobule being about the size of a pin's head, easily visible to the naked eye. Under the microscope it may be seen that in the center of this lobule there is a small blood vessel, the so-called "central vein," and radiating out from this, like the spokes of a wheel, are a great many columns of liver cells. Around the periphery of the lobule there is a small amount of fibrous connective tissue in which may be seen the small branches of the hepatic artery, of the portal veins, and of the smaller bile ducts. Within each column of liver cells, is a tiny delicate bile capillary in which the bile formed by the cells is collected; this bile flows toward the periphery of the lobule where it enters into the larger bile channels. Between the columns of liver cells lie the blood capillaries that carry the portal vein blood from the periphery of the lobule between the liver cells to the central veins. This blood, fresh from the gastro-intestinal tract, thus comes into intimate contact with the cells of the liver before it reaches the central veins. The blood from these central veins flows into ever larger hepatic veins, and finally into the vena cava inferior and the right side of the heart.

The functions of the liver must be very complex. Though we are ignorant of many of the details of its physiology, still its importance as a part of the digestive apparatus is generally recognized and we already know much about several of its special functions. The most obvious work done by the liver is the production of bile, a secretion that may be spoken of as the "external secretion" of the liver, since it passes out of the liver through a duct to enter into the intestinal canal. The other activities are sometimes spoken of as functions of "internal secretion," since they are manifest only in changes in the blood stream as it flows through the organ.

The bile leaves the liver by way of the so-called hepatic

duct, which, when joined by the cystic duct from the gallbladder, forms the common bile duct that passes through the head of the pancreas and the wall of the duodenum (first part of the small intestine), opening into the bowel a few inches below the lower end of the stomach. Surrounding the end of the bile duct as it passes into the intestine is a circular band of muscle, which serves as a sphincter; as this muscle relaxes the bile passes into the intestines, and when it contracts so as to close the duct it forces the bile back through the cystic duct into a lateral reservoir, the gallbladder.

The *gallbladder* is a thin-walled, pear-shaped sac, lying under the liver, its rounded larger end almost reaching the anterior abdominal wall just below the last rib to the right of the midline. When full it contains about 60 cc. (2 ounces) of fluid; its walls are both expansile because of their elasticity and contractile because of the muscular elements contained in it.

The walls of the gallbladder possess a remarkable power of concentrating the bile that is forced back into it; they absorb a part of the water and so increase the concentration of the other constituents of the bile to about six times that of the bile as it is secreted by the liver. During digestion the muscular ring at the mouth of the common bile duct relaxes at intervals, and at the same time the walls of the gallbladder contract, forcing the bile into the intestine.

The *bile* formed during twenty-four hours amounts probably to between a pint and a quart. The formation of bile goes on most actively after meals, during the digestion of the food, but a certain amount of secretion occurs continuously. The gallbladder serves as a storehouse for the bile between the periods during which it is being poured into the intestines; though small in size, it is able to store the bile because of its ability to absorb water from it and to concentrate the other ingredients.

The secretion of bile serves a double purpose—(1) that of ridding the body of waste products (analogous to those

excreted in the urine) and (2) that of supplying certain substances, especially the so-called bile salts, to the contents of the small intestines to help in the digestion of fats. Among the chief constituents of the bile are (1) water, (2) bile pigments which are derived from broken up red blood corpuscles and which give it its yellowish-green color, (3) bile acids or their salts, (4) cholesterin, a substance closely related to the fats, and (5) salts of calcium.

The internal secretions of the liver are related to the metabolism of the different food substances; the products of the digestion of these pass through the liver immediately after their absorption from the gastro-intestinal tract. The participation of the liver in the metabolism of carbohydrates is very important. In the intestine these are converted largely into glucose or grape sugar, and are absorbed as such from the intestines. The liver converts this glucose into another substance called glycogen (or "animal starch"); storing this up in its cells, it liberates it again when necessary to maintain a nearly constant concentration of sugar in the blood. This ability to store up glucose as glycogen and to give it off to the blood stream again as sugar, just when it is needed, is closely related to a certain function of the pancreas that is much disturbed in diabetes mellitus, of which more will be said in a later section.

In addition to its function in carbohydrate metabolism the liver also plays an important rôle in the metabolism of fats and in that of proteins. Thus the liver acts as a storehouse for fats, and its importance in the end stages of protein metabolism is shown by the fact that urea, the chief final product of protein metabolism, is formed in the liver, to be excreted later by the kidneys.

The liver is believed, furthermore, to exercise a general protective influence upon the body by catching and rendering harmless many poisonous substances that may reach the blood stream. It seems to have an especial affinity for a number of such substances, including (1) mineral poisons like arsenic and phosphorus, and (2) organic poisons like

chloroform, alkaloids (concentrated active substances derived from plants and frequently used as medicines), and (3) certain intermediary products of digestion that are toxic, such as indol and skatol, which are formed in the large intestine and undergo combination with other substances in the liver, to be later excreted in the urine.

Finally, the liver manufactures fibrinogen, the component of the blood that forms the larger part of the clot when that fluid coagulates. If the fibrinogen of the blood be deficient, the blood when shed may clot within the usual time, but the clot formed is so "weak," owing to deficiency in solid materials, that it may not be strong enough to stop bleeding from a wound, so that the oozing of blood may be unduly continued so as to be dangerous to the bleeder.

This enumeration of the functions of the liver will serve to show its great importance for the body. For the performance of its functions, the liver is, like the heart muscle and the kidneys, provided with factors of safety; it possesses considerable reserve power and also a remarkable ability to regenerate its cells after injuries. Thus, in experimental work upon animals, it has been shown that some three quarters of the liver may be removed with impunity, the remaining quarter soon enlarging to the original bulk of the organ; it has even been asserted that as much as nineteen-twentieths of the liver may be destroyed without serious damage to the animal! It would seem reasonable to assume, therefore, that, in order to produce serious symptoms of deficiency of liver function, most of the liver tissue must be involved in a disease process.

Certain Diseases of the Bile Ducts and of the Gallbladder.—Postponing further consideration of the functions of the liver substance itself for the moment, we may next refer to certain abnormal states of the bile ducts and of the gallbladder, for it is in these structures that most of the difficulties ordinarily spoken of by the laity as "liver trouble" arise. There is much confusion in the popular mind regarding the relation of biliary disturbances to symp-

toms. Thus, in some parts of the country one frequently hears the terms "biliousness" and "bilious attacks" mentioned. The conditions referred to by these terms are not very sharply defined, but they are usually associated with feelings of general discomfort or malaise and symptoms on the part of the stomach and intestines such as loss of appetite, nausea and perhaps vomiting, diarrhœa or constipation. In such states undoubtedly some disturbance of the gastro-intestinal tract exists, but there is no evidence whatever that the liver is in any way involved or that the bile plays any part in the production of the clinical picture.

The idea that a biliary disturbance is responsible may be due, perhaps, to the fact that the patients often get relief by taking calomel, which is followed by passage of bile-stained stools. Sometimes a mild inflammation may extend from the small intestine into the bile passages and cause sufficient swelling of the mucous membrane (with increased formation of mucus) to obstruct the outflow of bile. Owing to this obstruction, the bile is dammed back upon the liver, where it is absorbed by the blood capillaries, carried in the blood stream to all parts of the body, and deposited in the tissues. Some of this absorbed bile is excreted by the kidneys; the urine becomes dark in color and the foam formed on shaking the urine in a test tube will then be yellow. Staining of the tissues and of the urine with bile pigment is called *jaundice,* and when jaundice is due to an obstruction of the bile passages it is spoken of as an "obstructive jaundice." The commonest form of obstructive jaundice is that just described as due to the extension of a catarrhal inflammation from the intestines to the bile passages; it has, accordingly, been called "catarrhal jaundice." Although it may make its victim miserable for several weeks before it clears up, it is not at all a dangerous affection.

Obstruction of the common bile duct must always be followed by jaundice. Obstruction of the cystic duct (the duct of the gallbladder) does not cause jaundice, since the flow of bile from the liver to the intestines is not thus

obstructed. Obstruction of the smaller, hepatic ducts within the liver may, or may not, be associated with jaundice, depending upon the number and extent of the ducts involved. Besides catarrhal jaundice there are other forms of obstructive jaundice, some of which may be of a serious nature. Thus obstruction of the bile duct by gallstones or by pressure upon the duct from without (from tumors or from masses of inflammatory tissues) may necessitate surgical interference.

Abnormalities of the gallbladder may be of importance for the origin of degenerative diseases in two ways—(1) they may be responsible for the formation of gallstones and (2) they may make the gallbladder a focus of infection whence the liver or even more distant organs and tissues may become infected with inauguration of degenerative conditions.

Gallstones are solid concretions composed of certain constituents of the bile that have been precipitated from solution. The most common constituents of gallstones are cholesterin, bile pigment, and calcium salts. The concretions may vary in size from minute particles (spoken of as "biliary sand") up to very large stones, larger even than a hen's egg. Although only a single stone may be present, usually there are multiple stones, fifteen to twenty, or as many as a hundred or more. The commonest site for the formation of the stones is the gallbladder, although stones may also be formed within the ducts of the liver.

The presence of gallstones, constituting the condition known as "cholelithiasis," is by no means uncommon. Gallstones are demonstrable at autopsy in from 3 to 10 per cent of all cases, regardless of the immediate cause of death. Three-quarters of the cases have been among people over forty years of age, and less than 1 per cent of them among these are under twenty years of age. The malady is much more common in women than in men, and it is particularly prevalent among those who lead a sedentary life and are overindulgent in the pleasures of the table. The

aphorism has, accordingly, arisen that patients who are fat and forty are more liable to gallstone attacks than are their thinner and younger associates. Though no satisfactory evidence exists concerning the details of the relations of diet to the causation of gallstones, there is a general impression that a rich diet, especially one containing a great deal of fat, is of some etiological importance.

It is now believed that two of the most important factors in the production of gallstones within the gallbladder are (1) infections of the gallbladder and, (2) stasis, or damming back, of the bile. One very important infection in this connection is typhoid fever. Bile is a very favorable medium in which to cultivate the typhoid bacillus, and infection of the gallbladder with these bacilli is a frequent complication in the course of typhoid fever. Sometimes, after recovery of a patient, the germs persist in the gallbladder for many years. They may be given off in the bile, so as to pass down the bile duct into the intestinal tract and be discharged with the patient's excreta. A person who thus, though apparently healthy, gives off typhoid bacilli to the outside world is spoken of as a "typhoid carrier" and is a constant source of danger to the people of his community, particularly if his or her occupation have to do with the handling or the cooking of food. Most gallstones have a central nucleus formed either of the bodies of bacteria, of detritus from the walls of the gallbladder, or of mucus. Typhoid bacilli have been cultured from the center of gallstones many years after the occurrence of the typhoid fever. Another frequent bacterial invader of the gallbladder is the streptococcus, a very common germ that causes a variety of diseased conditions. The streptococcus is often responsible for acute diseases of the throat (including tonsillitis and infected adenoids); it is frequently found also at the roots of abscessed teeth. Bacteria may reach the gallbladder either by way of the blood stream or by way of the bile channels (from the intestines, especially in catarrhal conditions of the intestines). Pregnancy

seems to be a predisposing cause of cholelithiasis, probably because of stasis in the biliary passages due to displacement of the abdominal organs.

Prevention of Gallstones.—The decrease in the incidence of typhoid fever through preventive measures has occurred so recently that sufficient time has not yet elapsed to permit us to be sure of the effects that this improvement in public health may have upon the frequency of occurrence of gallstones. If physicians be right in believing that typhoid fever is an important predisposing cause of cholelithiasis, there is reason to expect that the control of that infection will have a favorable influence in preventing the formation of concretions within the gallbladder in at least many cases. The methods of prevention to be adopted against typhoid fever have been considered in earlier sections. The incidence of gallstone disease will probably be lessened also by the eradication of focal infections in tonsils, adenoids, teeth, and other parts of the body.

The other important prophylactic measures lie in the sensible conduct of life; if a normal state of nutrition be maintained, and if a proper amount of out-of-door exercise be taken, much will be done to prevent a disorder that is often accompanied by a great deal of pain and discomfort.

Degenerative Diseases of the Liver Itself

That large and very important organ, the liver, has, as we have seen, a remarkable power of resisting harmful agencies. Poisonous materials absorbed by the gastrointestinal tract pass first through the liver before reaching the general circulation. The liver thus occupies a dangerous outpost of the body's defenses, besides being subjected, like every other organ, to the influence of whatever harmful materials may circulate in the general blood stream. Despite these facts, it is comparatively rare for the physician to encounter cases in which he can be sure that the functions of the liver are gravely at fault. The reasons for this lie in our lack of complete knowledge of the functions

of the organ, in the great resisting powers it possesses, and in the large "margin of safety" that has been referred to. Even when gross lesions of the liver exist and are readily recognizable, such as a large abscess of the liver or a cancerous tumor secondary to a cancer in the gastro-intestinal tract, the symptoms are usually those of the infectious process or of the primary tumor rather than those due to any failure of the liver to perform its ordinary functions.

At post-mortem examinations it is not uncommon to find slight changes in the liver, though often strictly localized to small areas. In the bodies of persons dead of acute infections like typhoid fever or pneumonia, the liver often shows a changed appearance, spoken of as "cloudy swelling." The organ is then larger than usual and looks more opaque, as though it had been boiled; under the microscope the liver cells are somewhat changed. Extensive fatty degeneration may occur in the liver cells under similar conditions, as well as after poisoning with certain mineral substances or with alcohol. Even when the liver cells are distended with fat to the extent that of the total weight of the liver the fat amounts to 40 per cent instead of the usual 4 or 5 per cent, the function of the liver has apparently not been greatly disturbed. In some cases of chronic infection (tuberculosis, syphilis, or chronic pus-forming diseases of the bone) another type of degeneration occurs called "amyloid degeneration," in which a peculiar uniformly translucent material is deposited between the blood capillaries and the liver cells. This same process usually affects also the spleen, the kidneys, and other organs and tissues of the body, and the symptoms of the disease are referable to the primary pathological condition and to the secondary changes in the other organs rather than to those in the liver. Sometimes in acute infectious diseases like typhoid fever there are minute focal necroses or areas in which the liver cells have been killed by the poisons of the disease. These areas, as a rule, are widely scattered and

are not very numerous; but, in some cases, the process may involve a goodly portion of each liver lobule and it may show a definite preference for the same part of all the lobules affected, say the central area immediately around the hepatic vein, or the middle zone, or the peripheral portion of the lobule. In the acute poisoning (eclampsia) that sometimes occurs during the latter phase of pregnancy death of the liver cells in the peripheral part of each lobule is the most characteristic finding at autopsy.

The liver may be extensively damaged or even entirely destroyed in severe poisoning with chloroform, with certain mineral poisons (especially phosphorus, arsenic), with some anilin derivatives, and with other toxic substances derived from mushrooms or from altered meat. In persons or animals killed in this way, it is found that a large proportion of the liver cells have been entirely "wiped out."

There is a rather unusual disease of the liver, spoken of as "acute yellow atrophy," in which the appearance of the liver is somewhat similar to that seen in the acute poisonings just mentioned. It often happens, however, in such cases that the nature of the poison that produces this marked result is never determined. The disease is commonest between the twentieth and the thirtieth years of life and occurs more frequently in women than in men. It is assumed that some overwhelming intoxication occurs, somewhat analogous to that already mentioned in infectious, mineral, or vegetable poisonings.

Laboratory studies of such poisonings of the liver indicate that, on recovery from intoxications that were not severe enough to cause death, the bodies of the killed liver cells are very rapidly liquified and absorbed and the remaining liver cells quickly regenerate new cells to take the place of those lost. After chloroform poisoning, for instance, the liver is apparently "as good as new" again after a few weeks. Such is the behavior of the liver, then, after a single acute injury.

But if a number of different toxic factors are at work

continually, or at rapidly repeated intervals, the result may be quite different; instead of rapid replacement of destroyed cells, there may be a gradual loss of the liver cells, with replacement by fibrous connective tissue. This change has been experimentally produced by the use of combinations of bacterial and mineral poisons repeatedly administered, and by the injection of foreign protein materials. The condition of the liver thus arising is spoken of as "cirrhosis."

Cirrhosis of the Liver.—The word "cirrhosis" comes from a Greek word meaning "yellow." The condition of the liver might also be spoken of as sclerosis, in analogy to the sclerosis that occurs in the arteries and the kidneys, for the liver becomes extensively scarred and frequently deformed by bands of fibrous connective tissue that separate the lobules from one another or which may even invade the lobules.

Compared with the degenerative states of the heart, arteries, and kidneys already described, cirrhosis of the liver is an uncommon disease and hence is less important than they from the standpoint of the present discussion. It is much more common in men than in women. There are two general types of cirrhosis of the liver—(1) the so-called *portal cirrhosis* (atrophic cirrhosis or Laennec's cirrhosis), and (2) *biliary cirrhosis* (hypertrophic cirrhosis).

The first type is called *atrophic cirrhosis* because the liver is usually found to be smaller than normal. It is called *portal cirrhosis* because it is usually associated in its late stages with obstruction to the blood flow in the portal veins, with consequent damming back of the blood and congestion in the capillaries of the stomach, intestines, spleen, and peritoneal surface of the abdominal cavity. This ordinary type of cirrhosis of the liver occurs between the ages of forty and sixty years. The first obvious symptoms may be those caused by the congestion: (1) various symptoms of indigestion and (2) effusion of fluid into the peritoneal cavity (ascites). When the flow of the portal blood is

obstructed, the anastomoses (connections between the portal venous system and the general systemic venous system) attempt to carry the blood away by round-about routes and sometimes succeed in doing so. Thus in a case of cirrhosis one usually sees dilatation of the veins of the abdominal wall. There may be greatly dilated veins also appearing as hemorrhoids (piles) at the anus, or as œsophageal varices near the point of juncture of the gullet and the stomach. Should the latter veins be injured, extensive bleeding may occur into the stomach, and this blood may subsequently be vomited or be passed in the stools.

In most cases the cirrhotic disease of the liver will have existed for a long time before the evidence of portal obstruction has appeared. When ascites develops, the fluid in the abdominal cavity may reach enormous amounts and may cause great distress by its pressure, in which event it can be removed through a large hollow needle; some patients have to be repeatedly "tapped" in this way. After repeated tappings patients may apparently recover or at any rate remain free from accumulations of fluid in the abdomen and in fairly good health for many years, though this is unusual. Sometimes, through the establishment of a satisfactory collateral circulation, the onset of symptoms of portal obstruction may be prevented, but usually, once such symptoms have appeared, a collateral circulation is rarely satisfactorily achieved. In the terminal stages of atrophic cirrhosis there may be evidences of impairment of all of the functions of the liver.

In the causation of cirrhosis of the liver, it is probable that any of the harmful agencies mentioned as sometimes causing acute lesions in that organ may be factors, to wit, toxins of infectious processes, mineral poisons, other poisons from without, and certain toxic endogenous factors like those that arise during pregnancy. There is a strongly rooted impression among medical men that alcohol is the most important external cause of cirrhosis of the liver. It is quite common to obtain from a cirrhotic patient a

history of moderate or of excessive use of alcohol over long periods of time, and the disease is certainly more common among workers in breweries, distilleries, and saloons than among the ordinary population. Cirrhosis of the liver does, however, occur among total abstainers and among certain people (Chinese and Mohammedans) who do not consume alcohol at all. Overeating, various poisons arising from the intestinal tract, or recurrent poisoning from foci of infection in the body may be important factors. As we have already emphasized in previous sections of this book, the important factor of predisposition must always be reckoned with. Thus one man may have been a heavy drinker for years and be riddled with foci of infection, and yet show no signs of cirrhosis of the liver, whereas another man of comparatively good habits who has never used alcohol to excess may develop the disease in a well-marked form.

In the treatment of cirrhosis of the liver every effort should be made to correct any demonstrable fault in the dietetic and hygienic regimen and to eradicate all possible foci of infection, for, as we have already said, in some cases the process may apparently be arrested; then, and if the symptoms of portal obstruction can be overcome, the patient may enjoy fairly good health at least for a number of years.

Biliary Cirrhosis.—Under this heading two groups of cases may be considered. The first group is that of persons, usually between the ages of twenty and forty, who exhibit enlargement of the liver and spleen, slight or moderate jaundice, indigestion, perhaps pain over the liver region, and occasional attacks of slight fever. In these patients the liver is larger and less deformed than in portal cirrhosis, and there is no tendency toward obstruction of the portal vein. The fibrous tissue scarring takes place more uniformly throughout the liver tissue, the lobules are invaded by the scar tissue, and the small bile channels show evidences of catarrhal inflammation.

This condition is even less common than is atrophic or portal cirrhosis. Its causes are not definitely known, but they are generally assumed to be either of a toxic or of an infectious nature. The disease has been known to begin soon after an infectious disease; in a number of instances it has been closely associated with typhoid fever. It is probable that in some cases an infection of the larger bile passages that ascends into the small bile channels and thus reaches the liver may be the cause.

The second group of cases of biliary cirrhosis is that of older persons who develop it during the age of gallstone formation. In them the process seems to be due to a long-continued partial or complete obstruction of the bile ducts, usually by a gallstone or by many gallstones. The infection of the bile ducts that so commonly accompanies the formation and presence of stones is doubtless also a factor in bringing about the changes in the liver. When the liver of this type of cirrhosis is studied under the microscope, the evidences of inflammation, especially around the smaller bile passages, are much more obvious than in other forms of cirrhosis.

Prevention of Cirrhosis of the Liver.—There is good reason to believe that most, if not all, cases of cirrhosis of the liver, especially those of the commoner form (atrophic or portal cirrhosis), could be prevented. The prevention of general infections (like typhoid fever and malaria) that are considered to be related to this disease is partly a matter of public-health control and partly a matter of the intelligent co-operation of the individual with the public-health authorities, on the one hand, and with his private physician, on the other. The prevention of other infectious processes (focal infections in tonsils, teeth, gallbladder, etc.) predicate, on the part of the patient, a certain interest in preventive medicine and a consequent willingness to submit himself for medical examination at more or less regular intervals.

Alcoholic habits such as formerly gave rise to cirrhosis hepatis frequently are but rarely encountered nowadays.

The periodic drinker, even he that indulges in long debauches, is less threatened than is the steady drinker, who, though he takes several drinks each day, may never show signs of intoxication. Distilled liquors are considered to be much more dangerous as causes of cirrhosis than are malt or vinous liquors, although the *vin ordinaire* of France has been strongly incriminated by French authors. According to prevailing medical opinion, complete abstention from alcoholic beverages would prevent the development of many cases of liver cirrhosis, although it would not, of itself, prevent all cases. Anyone who shows, on physical examination, any evidences suggestive of a developing cirrhosis of the liver should stop the use of all alcoholic beverages at once, even though he may have used them strictly moderately. The other extraneous poisons capable of injuring the liver are probably of considerably less importance in the origin of cirrhosis than is alcohol. Chloroform is used as an anæsthetic now much less than formerly. Arsenic, however, is used probably a great deal more nowadays than it formerly was and it is given in much larger doses, especially in the treatment of syphilis. If on treatment with arsenic, evidences of liver damage should appear, the physician should stop the arsenical treatment and make use of other forms of medication.

Probably much could be done to prevent cirrhosis of the liver by educating people to eat more sensibly and to pay more attention to general hygienic rules. Besides a properly balanced diet, the avoidance of overeating (and of obesity), the insurance of satisfactory daily evacuation of the bowel, the drinking of sufficient quantities of water, and the avoidance of excessive absorption of putrefactive products from the large intestine would seem, in this connection, to be factors of importance.

The most important preventive measures against the biliary type of cirrhosis of the liver are (1) those that deal with the prevention of infections, and (2) those that have to do with the treatment of gallstones and of infections

of the biliary tract after they have been discovered. Patients who suffer from recurrent gallstone attacks, or who show evidences of infection of the gallbladder or the bile ducts, should probably resort to surgery; if the gallstones are removed and the gallbladder be drained satisfactorily or removed entirely, the dangers of a secondary cirrhosis will be abolished. The mere presence of gallstones in the gallbladder (in the absence of marked infection) is comparatively innocuous, but stones within the bile ducts may be a source not only of great discomfort to the patient, but also of potential damage to the liver, and, as we shall see in a later section, to the pancreas as well. It should be remembered, too, that chronic infection in the gallbladder may serve as a focus from which infectious processes elsewhere in the body originate.

Degenerative Diseases of the Pancreas

Structure and Function of the Pancreas.—The pancreas is situated on the posterior wall of the abdominal cavity, just in front of the spinal column and the large heavy muscles of the back, and behind the stomach. It is an elongated organ extending transversely across the body. It measures from five to eight inches in length and weighs usually about three ounces. The gross appearance of the pancreas of animals is familiar to most housekeepers, since they use it, in the form of sweetbreads, as food. The so-called "head of the pancreas" partially surrounds the duodenum (first portion of the small intestine) and through it passes the common bile duct on its way to open into the duodenum. The tail of the pancreas extends lateralward, to the left, where it comes into contact with the spleen.

The pancreas is divided into very small lobules, each lobule containing a number of small clusters of cells that surround a tiny opening in the center communicating with the ducts of the organ. In addition to these ordinary cells of the pancreas, which pour their secretions through ducts into the intestinal tract, there are other small collections of

cells just visible to the naked eye scattered about through the pancreas. These small groups of cells, more common in the tail of the pancreas than in its head, are spoken of as the "islands of Langerhans"; they have no connection whatever with the ducts of the pancreas and their function is entirely distinct from that of the rest of the organ. The island cells have to do with the metabolism of carbohydrates (starches and sugars) within the body. They pour their secretion (the "internal secretion" of the pancreas) into the blood stream, so that this portion of the pancreas is analogous to a "ductless gland." More is said concerning these peculiar structures and their relationship to diabetes in another section.

The secretion from the chief portion of the gland passes through delicate conducting channels and thence through ever larger ducts to enter finally into the intestinal canal. Here it is of the greatest importance for the digestive processes. It contains several different kinds of ferments or enzymes—that is to say, substances recognizable only by their action in bringing about chemical changes in organic materials such as those of the food. Ferments or enzymes of the gastro-intestinal tract (and of its associated glands like the pancreas) are responsible for the digestion of the food. The pancreatic enzymes include (1) trypsin, which splits up the protein constituents of the food within the intestinal canal, (2) amylase, which breaks down the carbohydrates, and (3) lipase, which splits the fats.

The main ducts of the pancreas extend through the length of the gland and open into the duodenum, usually in association with the common bile duct. This arrangement of the ducts is of considerable importance in the causation of some of the disease processes that occur in the pancreas. Sometimes the pancreatic duct opens into the duodenum quite independently of the bile duct—that is, at a little distance from the opening of the latter—but the usual arrangement of the ducts is such that the pancreatic duct and the common bile duct unite to form a little chamber that is spoken of as the

"ampulla of Vater." This chamber opens into the duodenum at the apex of a little prominence spoken of as the "papilla of Vater." It has been demonstrated that the structural arrangement of these ducts (in about 60 to 70 per cent of human beings) is such that a small gallstone may become impacted in the ampulla of Vater in such a way as to obstruct the opening into the duodenum and yet at the same time permit of a free passage of materials from one duct into the other. This occasionally results in the passage of bile into the pancreatic duct and so into the pancreas itself. It is now generally believed that many pancreatic lesions (both acute lesions and those of chronic degenerative states) originate in this way. If the bile be badly infected the result in the pancreas may be quickly disastrous, but if the bile be normal bile and contain some mucus from the gallbladder, very little harm may be done; or, again, if the bile come directly from the liver without admixture of mucus from the gallbladder, the degree of damage is prone to be midway between that of infected bile, on the one hand, and that of normal mucus-containing bile from the gallbladder on the other.

Other methods by which the pancreas may be injured have also to be considered. Bacteria or their toxic products may reach the pancreas through the blood stream and cause so-called "focal necroses" (small areas in which the pancreatic cells are killed) with an inflammatory reaction around them. These necroses have been met with in a number of infectious processes. Then, too, like the kidney, the heart muscle and other organs and tissues, the pancreas is dependent upon an adequate supply of blood; it is damaged when the blood supply is cut off or markedly diminished (as may occur in arteriosclerosis or when venous blood is dammed back upon the pancreas because of obstruction to the portal veins in cirrhosis of the liver or of chronic heart disease). Cloudy swelling and fatty degeneration may occur in the pancreatic cells as they may at times in the cells of the liver or of the kidneys and under the same circumstances.

The chronic degenerative lesions of the pancreas are usually spoken of as "chronic pancreatitis," just as those of the kidney are called chronic nephritis, those in the heart chronic myocarditis, and those in the liver chronic hepatitis (usually spoken of as cirrhosis of the liver). We might speak of a cirrhosis of the pancreas or of a sclerosis of the pancreas, since the processes are essentially similar to those of the same name in the liver. The changes consist of a degeneration and gradual disappearance of the essential cells of the organ, with replacement by growth of connective tissue. As in the liver, there are two general types of this chronic change, one in which the new connective tissue surrounds the lobules or groups of lobules, and another in which the new connective tissue (or scar tissue) invades the lobules themselves diffusely. The former type of change is usually caused by some obstruction to the ducts of the gland or by extension of infection from the ducts; in this form the islands of Langerhans are practically unaffected. The second, or more diffuse, type is usually associated with cirrhosis of the liver or with general arteriosclerotic changes; in this form the islands, as a rule, participate in the injury.

Except in advanced cases, chronic degenerative states of the pancreas are usually not detected during the life of the patient. Symptoms may, however, arise in a number of ways. Thus, a lack of sufficient pancreatic juice in the intestinal tract may cause symptoms of indigestion and is usually associated (1) with large, drab, shiny stools, due to the presence of fat that has not been broken up and digested and (2) with the passage in the stools of large amounts of nitrogen-containing substances derived from undigested protein of the diet. Again, damage to the islands of Langerhans beyond a certain degree results in diabetes mellitus. Or, still again, chronic inflammations in the head of the pancreas may compress the common bile duct and cause a severe obstructive jaundice.

Prevention of Chronic Degenerative Diseases of the Pancreas.—Prevention of these diseases, as will be readily

appreciated from the foregoing statements, involves the prevention of (1) cirrhosis of the liver, (2) arteriosclerosis, (3) gallstones, and (4) infections of the biliary tract. A large proportion of pancreatic lesions are associated with abnormalities in the bile ducts and gallbladder. The special features of protection of the islands of Langerhans and of prevention of diabetes mellitus will be considered later.

CHAPTER XVIII

DEGENERATIVE DISEASES OF THE NERVOUS SYSTEM

Structure and Function of the Nervous System.—The nervous system includes (1) the brain, within the cranial cavity; (2) the spinal cord, inclosed within the vertebral column; and (3) the peripheral nerves with their ganglia (collections of nerve cells). The brain and the spinal cord together make up the so-called central nervous system in contradistinction to the peripheral nervous system. The brain and the spinal cord are made up of nerve cells of a great many different kinds, of nerve fibers, of the blood vessels that nourish them, and of a peculiar connective tissue called neuroglia. The central nervous system is covered by several layers of membranes called the meninges. The inner layers (the pia mater and the arachnoid) next to the nervous tissues are soft, thin, and pliable, and conform closely in shape to the nervous tissues immediately underlying them. The outer layer (the dura mater) is a thick, coarse, fibrous envelope. Beneath the dura mater, in the so-called subdural spaces, is a clear fluid (the cerebrospinal fluid), which serves as a cushion for the nerve tissues. This fluid surrounding the brain and the spinal cord is continuous through small openings with that in the ventricles of the brain, which are four fairly large cavities within the brain substance. The gray matter of the brain includes a part close to the surface (cortex of the brain) and a part at the base of the brain called the basal ganglia. The gray matter of the spinal cord occupies a more central position; it contains the nerve cells. The white matter of the brain and of the cord consists chiefly of nerve fibers. These nerve fibers of the

central nervous system connect various portions of the gray matter of the brain with one another and also extend in long paths or tracts from the brain to the spinal cord or similar paths running in the opposite direction.

The functional unit of the nervous system consists of a nerve-cell body with many processes; these processes are largely structures for the reception of nerve impulses (dendrites), but one particularly well-developed process, the axis cylinder, which may extend to a great distance from the nerve cell, is believed to carry nerve impulses away from the body of the nerve cell. This system, composed of nerve-cell body, dendrites, and axis cylinder, as a whole constitutes a functional unit known as the "neurone." Nerve fibers contain axis cylinders. Within the central nervous system and in many of the peripheral nerves each axis cylinder of a nerve fiber is surrounded by a sheath of fat-like tissue called the myelin sheath, very much like insulation on an electric wire. Of the peripheral nerves, the main motor nerves going to the skeletal musculature and the sensory nerves coming from the skin are provided with these myelin sheaths (medullated), whereas the nerve fibers of the autonomic nervous system, having to do with the nerve supply of the viscera of the body, are not provided with myelin sheaths (non-medullated).

Nerve cells that subserve similar functions are found grouped within the central nervous system in "nerve centers" or "nuclei"; similarly special paths or tracts carry nerve fibers that subserve a common function.

Studies of the development of the nervous system in embryos, of electrical stimulation of portions of the brain, and of degeneration of nerve fibers after injuries of known extent, have taught physicians much concerning the relationships of the nerve centers to the various nerve paths. The nervous system is known to be, in many respects, the most wonderful, as it is the most important, of the body systems, though it must be admitted that the precise mode of its functioning in all details is still far beyond the present state

of scientific knowledge. Through the nervous system, the manifold activities of the whole body are co-ordinated; in it originate, too, the still more marvelous higher psychic functions.

The conception of the nervous system as made up of functional units or neurones has been of the greatest help in unraveling its mysteries. The cell body (with its nucleus) is necessary for the life and vigor of the whole neurone; if the cell body be destroyed, the whole neurone perishes. If an axis cylinder process be interrupted at any point in its course, that part of the nerve fiber that thus becomes separated from the body of the nerve cell degenerates and dies. It is possible by special anatomical methods of investigation to trace such degenerated fibers and tracts throughout their course in the brain and the spinal cord, and similar methods can be utilized for the study of the course of fibers in the peripheral nerves.

We have already referred to the fact that nerve cells and fibers that have to do with similar functions tend to be grouped together. Thus the nerve cells that inaugurate voluntary movements of one side of the body are situated within the cortex of one of the hemispheres of the brain, and nerve fibers pass downward from them toward the base of the brain, where they become collected into a compact bundle; they cross over to the other side of the spinal cord and run downward in a path known as the pyramidal tract, to terminate finally at different levels in the gray matter of the cord, where they come into association with other motor nerve cells. The latter send their axis cylinders into the peripheral nerves to supply the various skeletal muscles of the body. The right side of the brain cortex, therefore, governs the movements of the muscles of the left side of the body, and *vice versa*. There are at least two neurones involved in this motor tract—(1) the upper motor neurone, which extends from the cortex of the brain to the gray matter of the spinal cord, and (2) the lower motor neurone,

which extends from the gray matter of the cord to the muscle.

The sensory nerves that bear impulses from the periphery to the central nervous system extend from the delicate end structures in the skin or other tissues through the peripheral nerves to the small ganglia or collections of cells on the dorsal roots of the peripheral nerves, and then enter the spinal cord. The cells in these ganglia give off nerve fibers that pass up the cord, some of them on the same side and others on the opposite side from the point of entrance into the cord. They form the first links in chains of sensory neurones that ultimately reach the sensory areas of the brain cortex, which lie just behind the motor areas.

Just as there are motor and sensory areas in the brain, so there are areas also for vision, for taste, for hearing, for speech, for the maintenance of equilibrium, and for the mediation of still other functions. In the medulla oblongata (the portion of the brain stem next to the spinal cord) are located the vital centers for respiration and for vasomotor regulation. Hence a lesion so small as elsewhere in the brain to be of little moment may, in the medulla, be fraught with very serious consequences.

From the sensory fibers entering the cord branches (collaterals) arise, which end in processes around the motor cells of the same segment of the cord. A so-called reflex arc is thus formed. Movements inaugurated through stimulation of the sensory limb of such an arc are called "reflex movements"; they are involuntary movements. Thus, if the tendon just below the knee-cap be tapped while it is under slight tension, there will occur a kicking movement without any exercise of the will on the part of the subject. For diagnostic purposes methods of testing the integrity of various reflex arcs have been devised.

When an injury from any cause occurs in the brain or spinal cord, the interrupted nerve fibers undergo secondary degeneration. If the injury sever a motor tract, descending degeneration will follow, whereas ascending degeneration

occurs if a sensory tract be involved. Similarly, secondary degenerations of the nerve fibers and their myelin sheaths result when peripheral nerves are injured.

Lesions of the motor system may involve either the upper motor neurones or the lower motor neurones. When the lower motor neurones are involved there is "flaccid paralysis" of the parts affected; not only do the nerves degenerate, but the muscles to which they go also lose their tone and become atrophic and flabby. When the upper motor neurones are injured without simultaneous injury of the lower motor neurones, the muscles that are paralyzed do not lose their tone, but become more rigid than usual; such a condition is spoken of as "spastic paralysis." It seems as though some inhibiting force were removed from the lower motor neurones when the upper neurones are injured.

By studying the phenomena of motility, of sensibility, and of co-ordination in a patient, physicians determine whether or not an organic or structural disease of the nervous system exists. Through their knowledge of the localization of the various centers in the brain and spinal cord and of the tracts of nerve fibers leading to and from these centers, they attempt to determine at what point in the nervous system a given organic lesion is located; and, finally, often with the aid of other special tests they endeavor to ascertain the exact nature of a lesion and its cause.

It follows from what has already been said that, regardless of the cause of a lesion or of its location in the nervous system, a secondary degeneration of the nerve fibers and of their myelin sheaths is almost sure to occur after injury has taken place. Very small lesions and lesions at certain special sites may give but very little evidence of their existence and so be difficult of detection. Lesions of variable size may, for example, occur in the so-called "silent areas" of the brain without giving rise to symptoms sufficiently characteristic to enable physicians to localize them. There is a degenerative component, however, in practically all organic diseases of the nervous system. Some of these

maladies are exquisite examples of degenerative diseases; indeed, the degeneration of the nervous tissues may be secondary to other primary degenerative processes—for example, arteriosclerosis.

Factors in the Causation of Degenerative Changes in the Nervous System

1. Heredity.—On the constitutional make-up of our nervous systems depend our intelligence, our aptitude for work, our industry or slothfulness, our moods, whether of depression or of elation, our disposition, our whole outlook upon life—in short, the many qualities and characteristics that go to make up our personalities. Physicians daily have opportunities to note that the constitution of the nervous system in their patients depends in great measure upon hereditary factors. In the realm of nervous diseases a pathological inheritance is often manifest. Even functional nervous states are prone to develop in persons of so-called neuropathic inheritance; definite psychotic and psychoneurotic trends are often recognizable in several members of the same family. A good example is the so-called "psychasthenic trend," characterized by overconscientiousness, overparticularity, difficulty in making decisions, and in abiding by them, and fears (or phobias) of one sort or another. Another is the "manic-depressive trend," associated with marked variability of mood, victims of this trend being at times exceedingly enthusiastic and optimistic, at other times decidedly lugubrious and pessimistic. Still another example of hereditary nervous instability is to be seen in "migraine" (periodic sick headache), that incapacitates persons at intervals for a day or two; such headaches usually appear at about the time of puberty and occur at intervals throughout life, though in women they may disappear entirely at the menopause.

But it is not these functional nervous troubles only that can frequently be traced to hereditary influences; there are many structural degenerative conditions of the nervous

system for which the tendency may be directly inherited, apparently as Mendelian characters. Fortunately these are not very common diseases, but they are certainly interesting examples of the influence of heredity in human beings. Some disease tendencies are apparently transmitted as "dominant" Mendelian traits, others as "recessive" characters. Among the former we may mention the disease known as Huntington's chorea, characterized by a late onset (between the thirtieth and fortieth year), by disorderly, irregular, inco-ordinated muscular movements, by slow and difficult speech, and by mental impairment that leads finally to dementia. Families are known in which this disease has recurred for fully two centuries.

Among the nervous diseases the tendency to which depends apparently upon recessive Mendelian characters are (1) hereditary spastic paralysis, (2) congenital deaf-mutism, (3) retinitis pigmentosa, (4) myotonia congenita, (5) certain forms of imbecility, and (6) certain forms of insanity, notably dementia præcox.

From what has been said in preceding sections of this book concerning dominant and recessive heredity, it will be readily understood why it is that a disease like Huntington's chorea, dependent upon a hereditary character that is dominant, is prone to appear in the children of a patient who is married to a person of sound nervous stock, and that, on the other hand, diseases dependent upon recessive characters do not appear in the offspring of patients mated with those of sound nervous constitution though the hereditary factor for the disease remains latent in these offspring and may become manifest in subsequent generations if two persons possessing this same taint should ever marry. Hence the diseases that depend upon recessive characters are more frequently met with among the offspring of consanguineous marriages (*e.g.*, marriages of first or second cousins). The more widely distributed the hereditary recessive taint in the general population the less necessity there is for consanguinity in marriage for the disease to appear.

For example, dementia præcox is a fairly common disease; it is associated with a relatively low incidence of close parental blood relationship (only about 2.2 per cent), whereas for the much rarer disease known as retinitis pigmentosa the incidence of consanguinity is about 16 per cent.

Theoretically, it is of course possible to prevent these hereditary diseases, for if the victims of these conditions never had children the diseases would disappear. Practically, there are many difficulties in the way of application of the necessary preventive measures. Interest in eugenics has not advanced as yet to a stage where any marked success is possible in the prevention of the lamentable conditions to which we have just referred.

2. Trauma and Other Mechanical Factors.—As examples of traumatic injuries to the nervous system may be mentioned the traumata associated with instrumental delivery of infants which are responsible for the so-called birth palsies. Severe falls, or blows, upon the head may result in injuries to the brain by concussion, with or without a fracture of the skull. It is believed by some physicians that certain cases of epilepsy are due to the scars of lesions received in this way years before the onset of the symptoms of the disease. Fractures of the spinal column are often associated with displacement of portions of the bone resulting in pressure upon the delicate nervous tissues of the spinal cord; they may cause death or, in case of recovery, may result in degenerative changes associated with paralysis of the muscles of the body and with marked sensory disturbances below the level of the lesion. Sometimes there may be recovery from the paralysis of the voluntary muscles and only a bladder paralysis remain as evidence of the earlier injury. Such a paralysis of the bladder musculature is associated with an inability to void the urine, constant distention of the bladder, and damming back of the urine through the ureters upon the kidneys, with consequent damage to the function of the kidneys. A similar disturb-

ance of the bladder is sometimes seen in other degenerative conditions of the spinal cord—for example, locomotor ataxia.

Slow and gradually increasing pressure upon the spinal cord or brain may also result in degenerative changes. A fairly common type of such degeneration is that caused by the pressure of tuberculous inflammatory products upon the spinal cord in Pott's disease (tuberculosis of the spine). Finally, electrical shocks, sun stroke, and other purely physical agents may cause damage to the nervous system and result in degeneration of the nervous tissues.

3. Exogenous Chemical Factors.—A. *Infections with Micro-organisms and Intoxications Following such Infections.*—The damaging effect of infections upon the nervous system may occur either by the direct infection of the nervous tissues themselves by micro-organisms, or indirectly by means of the toxins generated by bacteria in inflammatory foci elsewhere in the body. As examples of the direct invasion of the nervous tissues by micro-organisms we may mention first and foremost the lesions due to syphilitic infection of the nervous system. Other important direct infections include the various types of encephalitis (infection of the brain), of poliomyelitis (infection of the gray matter of the spinal cord), and of meningitis (infection of the meninges, the coverings of the brain and cord). The so-called encephalitis lethargica has unfortunately found many victims during the past few years, apparently following upon the recent epidemics of influenza. Just what relationship exists between these two conditions is not yet definitely known. Lethargic encephalitis may involve different regions of the brain or a single portion to a much greater extent than others, with the consequent production of a great variety of different clinical pictures.

A well-known form of poliomyelitis is the so-called infantile paralysis; it is caused, it is believed, by a filterable virus.

Of the various types of meningitis, the commonest form

is acute cerebrospinal fever caused by a micro-organism known as the meningococcus. The treatment of this much-dreaded disease has been greatly improved by the introduction of Flexner's antimeningococcus serum into the spinal canal of the patient. In some of the patients that recover from the acute disease, there may be pronounced residual symptoms due to irremediable degenerative changes in the nervous system. Thus deafness is a common sequel of cerebrospinal meningitis.

The most common and the most important of all infections of the central nervous system is that due to the virus of syphilis. Several clinical types of syphilis of the nervous system are known. Meningitis may be a prominent feature in some patients, or a gumma (the local lesion of the third stage of syphilis) may form in the brain or in the spinal cord and destroy a certain amount of tissue. Another common type of syphilitic disease is that due to infection of the small arteries of the brain, the so-called syphilitic endarteritis, which may lead to hemorrhage or to obstruction of an artery with the production of an apoplectic stroke and of subsequent paralyses not unlike those associated with arteriosclerotic changes to be mentioned later. Besides these more or less localized syphilitic processes in the central nervous system two exquisite examples of more diffuse degenerative changes brought about by syphilitic infections must be mentioned. One of them affects chiefly the brain and is associated with a progressive mental deterioration; it is called general paresis, general paralysis of the insane, or dementia paralytica. The other, one of the commonest of degenerative nervous diseases, affects certain pathways in the spinal cord; it is the familiar locomotor ataxia, in which the degeneration involves particularly the posterior columns of the spinal cord, and is characterized by sensory disturbances, by inco-ordination of the muscular movements, by lightning pains in the extremities, and, sometimes, by paralysis of the bladder, by atrophy of the optic nerves, or by other signs and symptoms.

The nervous system may be indirectly injured by the poisons arising from infectious processes located in the body outside the nervous system. Thus the nervous disease known as multiple sclerosis is thought by many physicians to stand in an important relation to certain infectious diseases, particularly scarlet fever, typhoid fever, and other diseases in which poisons are widely distributed through the body. Multiple sclerosis is a chronic disease of the brain and cord, characterized anatomically by localized areas of myelin sheath degeneration with more or less replacement by neuroglia (connective tissue of the central nervous system). This disease is more common in females than in males and its onset usually occurs before the thirtieth year of life. Since the localized areas are distributed with no great regularity throughout the nervous system, the symptoms and signs may vary a great deal in different cases. Disturbances of vision and of speech, muscular tremors and spastic paralysis of the legs, are common symptoms. A rather striking feature is the tendency toward spontaneous remissions during which there may be marked improvement for a time. The actual cause of this interesting disease has not yet been determined; hence many possible etiological factors have been suggested. The general impression at present is that the disease is due to the deleterious effects of some external environmental factor (*e.g.*, infection or intoxication) upon a constitutionally weak nervous system, the constitutional weakness in turn being due either to hereditary defect or to early developmental defect.

B. *Alcohol, Tobacco, Lead, Arsenic, and other Poisons.*— As we have already indicated, there is a considerable personal equation in alcoholic poisoning. There is also a marked difference among different individuals in tissue susceptibility to this poison. The nervous tissues of some persons are peculiarly susceptible, whereas those of other people seem to be remarkably resistant to its effects. The members of the former class become quickly intoxicated with relatively small doses. The chronic use of alcohol may produce

marked structural changes in certain persons. There may be a destruction of some of the cells of the cortex of the brain, a gradual degeneration of many of its nerve fibers, and an increase in the fluid that bathes the nervous tissues, culminating in the pathological condition spoken of as "wet brain." A marked degeneration of the cerebral arteries with minute hemorrhages diffusely scattered throughout the cerebral cortex may also occur in chronic alcohol poisoning. In addition to the cerebral changes, degenerations may occur within the spinal cord. When the peripheral nerves undergo degeneration in alcoholism we speak of alcoholic neuritis.

The evidences of chronic alcoholic poisoning appear insidiously. The patient exhibits increasing irritability, lack of consideration for others, and neglect of his social responsibilities. Later evidences of permanent deterioration of judgment and memory make their appearance. Several well-defined clinical pictures of chronic alcoholism are known; they include (1) delirium tremens, (2) wet brain, or serous meningitis, (3) acute alcoholic hallucinosis, (4) dipsomania, or periodic drunkenness, and (5) the Korsakoff psychosis.

Delirium tremens may occur in a chronic alcoholic addict at the onset of an infectious disease or after a severe trauma or after sudden cessation of the use of alcohol. The condition is a serious one, the mortality in uncomplicated cases being usually about 15 per cent. It is characterized by sleeplessness, muscular tremor, and delirium with hallucinations of sight and of hearing. The patients assert that they see many small black moving objects. Usually these hallucinations have a horrible aspect to the patient, who may experience the very extremities of terror.

In dipsomania the inebriety is periodic. Many of the victims are really sufferers from a manic depressive psychosis or from some other form of mental disturbance.

The Korsakoff psychosis is a chronic delirium, associated with the complete disorientation of the patient as to time, place, and persons, with remarkably circumstantial and

detailed pseudoreminiscences. Frequently it is associated with a peripheral neuritis (a degenerative change in the peripheral nerves) with partial paralyses of certain muscles and with sensory disturbances.

Addiction to morphin, heroin, cocain, or other narcotics may cause serious and lamentable degenerations of the personality and be responsible for much distress and even for crime. Poisonings with these drugs are not, however, associated with characteristic structural changes in the nervous system that are recognizable by the means at present at our disposal.

The effects of tobacco in bringing about structural changes in the nervous system is much less well understood. That tobacco is a nerve poison seems quite obvious. The tremors, the feelings of nervousness, and the general impairment of mental activity that follow excessive indulgence all point in this direction. We have already mentioned the reports of nerve degeneration following its use. It is probable that some of the circulatory changes attributed to poisoning by tobacco may be due to a functional derangement of the sympathetic nervous system.

Lead and arsenic may be responsible for characteristic degenerative lesions of the central nervous system and of the peripheral nerves. A frequent result of lead poisoning is "wrist drop" due to paralysis of the extensor muscles of the hand following upon degenerative changes in the peripheral nerves.

4. Endogenous Factors.

A. *Change in Blood Supply.*—The commonest degenerations of the nervous system are due to defective blood supply. The reader will recall that in the discussion of arteriosclerosis the fact was emphasized that the secondary changes in the nervous tissues induced by the arterial disease are among the most important of the terminal events of that malady. A disturbance in the blood supply of the nerve tissues of the brain may be brought about in several different

ways. It may occur suddenly, either through rupture of a small artery or by the plugging of the artery with a blood clot, or by the lodgment in a small artery of a fragment of blood clot broken off from a larger clot somewhere else in the vascular stream (for example, on the walls of the heart or from vegetations from a heart valve). These three incidents are spoken of, respectively, as cerebral hemorrhage, cerebral thrombosis, and cerebral embolism. Such a sudden accident, if it occur in a vessel of fair size, may produce fulminant results. Thus the patient may fall unconscious, an event spoken of as "a stroke of apoplexy." If the patient recover from this sudden stroke, the subsequent degenerations in the nervous system will depend, of course, entirely upon the location of the arteries affected and the portion of the brain substance that dies and undergoes softening as a result of the loss of its blood supply, or which has been injured by the extravasation of blood. One of the regions most frequently involved is an area near the base of the brain where the motor tracts are aggregated into a small bundle; the clinical result of lesions here is a spastic paralysis of the muscles on the opposite side of the body. If the lesion be in the left side of the brain and the paralysis on the right side of the body, there is sometimes associated also a loss of the power to pronounce words (motor aphasia). In favorable cases there is often marked improvement after the stroke; thus the paralysis of the face may entirely clear up, and that of the leg become scarcely noticeable, but the disability of the arm tends to persist longer than that of the other parts. Sometimes one and the same person may suffer two, three, or more such strokes; often, however, the initial stroke is fatal.

Instead of a sudden occlusion or a rupture of a vessel there may be a gradual diminution and cutting off of the blood supply to the brain, with gradual and slowly progressing mental deterioration or other evidences of a more or less generalized nervous lesion. This is what often occurs in

the senile brain. Sometimes the nuclei of gray matter near the base of the brain are most affected, in which event a rather characteristic association of symptoms occurs—there is usually muscular rigidity, with coarse tremor of the muscles, a face that is mask-like or shows very little play of expression, a monotonous slurring speech, a stooped posture, a tendency to fall forward or to fall backward, and a gait characterized by very short steps. This is the so-called Parkinsonian syndrome, which sometimes appears in late middle life; despite the pronounced disturbance of motility, the mental powers may remain unimpaired for years. Somewhat similar clinical pictures may develop also in encephalitis lethargica (the so-called sleeping sickness or epidemic encephalitis).

B. *Pressure and Destruction by Tumors.*—Tumors may originate within the brain or spinal cord, or, originating in the meninges or in the overlying bone, they may cause pressure upon the underlying nervous tissues. Benign growths injure the nervous system chiefly by their pressure effects, whereas the more malignant tumors infiltrate and destroy the nervous tissues in addition to bringing about degenerative changes by means of pressure. A tumor within the skull (brain tumor) can cause effects of two kinds: (1) general effects and (2) local effects. The general effects are due to the generally increased intracranial pressure, more or less equalized throughout the contents of the skull; they are manifest clinically in disturbances of vision, swelling of the optic nerve, with subsequent degeneration and atrophy, nausea and vomiting, and a slow pulse rate. The local effects of the tumor depend entirely upon the location of the tumor within the brain. By recognizing the symptoms of general increased intracranial pressure, the physician can make a diagnosis of the presence of some space-filling mass inside the skull cavity, and by a study of the local pressure manifestations the neurological surgeon may be able to locate the tumor more closely so as to remove it by operation.

C. *Metabolic Changes.*—Metabolic diseases may be associated with degenerative nervous changes. A typical example is beri beri, a dietary deficiency disease in which there is a peripheral neuritis as well as degenerative changes in the cells of the brain and of the spinal cord. In another metabolic disorder, diabetes mellitus, a secondary multiple neuritis and degenerative changes in the posterior columns of the cord may develop; the symptoms resulting from these changes in the nervous system are sometimes referred to as diabetic tabes. Parts of the sympathetic nervous system may also undergo degeneration in diabetes. In pellagra there are more or less characteristic degenerative changes in the lateral and in the posterior columns of the spinal cord; the brains of those pellagrous patients who have shown mental deterioration during life also show structural changes at autopsy. We are still in doubt as to the exact etiology of pellagra; some believe it to be due to a food deficiency, some to obscure metabolic disorder, and some to infection with some organism from without.

Pernicious anæmia, also, may be associated with degenerative changes in the nervous system. The cause of the disease is entirely unknown. In this disease, there is an excessive destruction of blood as well as imperfect blood formation. Disturbances of the functions of the gastro-intestinal tract are present in all cases. Marked degenerative changes of the central nervous system, involving chiefly certain tracts in the spinal cord and to a less degree those of the brain and of the peripheral nerves, may develop. This form of anæmia is a common and rather widespread disease occurring in middle life. It is almost twice as common in men as in women.

Tropical sprue is still another disease of obscure etiology that has many resemblances to pernicious anæmia, including the degenerative changes in the nervous system. A micro-organism has been described as the cause of this disease, though it has not yet been generally accepted as the true etiological agent.

The Prevention of Degenerative Processes in the Nervous System

In these days of strenuous industrial activity and of high-powered vehicles for rapid transit, it is scarcely conceivable that traumatic injuries involving the central nervous system can be wholly eliminated. Accidents will, doubtless, continue to occur, and probably in increasing number, despite the safeguards provided for industrial employees and the legislation designed to regulate railway and automobile traffic. Once trauma of the nervous system has occurred, something may be accomplished in the way of preventing the more serious sequels by timely and proper surgical treatment, by relieving pressure, and by maintaining the bony parts in position until healing has taken place.

In the prophylaxis of the non-traumatic nervous diseases the main emphasis is to be placed upon (1) the avoidance of infections that injure the nervous system and (2) education in modes of living that discourage the development of arteriosclerotic changes.

Among the infectious diseases that do harm to the nervous system, syphilis ranks first. Syphilis is very widespread. Exact figures as to its prevalence are not obtainable, since the disease has been made legally reportable only in the past few years. It has been estimated, however, by Vedder that 20 per cent of the young men who enlist in the army and from 2 per cent to 5 per cent of the candidates for admission to colleges are infected. More than half of all prostitutes are said to be infected with syphilis, and many of these are in a stage of the disease in which the virus can easily be transferred to others.

Though the disease is usually contracted as a venereal infection, it may undoubtedly be acquired in other ways—for example, by the use of common drinking cups, common towels, toilet articles, and eating utensils. Physicians and nurses, because of their occupations, are not infrequently sufferers from "syphilis innocens." In the second stage of the

disease ulcers on the skin, on the lips, and on the lining of the mouth are common; and in the discharges from the surfaces of these minute ulcers there are great numbers of the organisms that cause the disease.

Until the onset of the World War the public health authorities had made very little effort to fight syphilis or other venereal diseases. But the successes that attended the application of the methods adopted by the United States Army, Navy and Public Health Service, in protecting the men in service against venereal infections, have been very stimulating to public-health activities since the war.

The methods for the control of syphilis suggested by the committee of the American Public Health Association can be summarized as follows:

(A) Control of the infected individual and his environment.

(1) Recognition of the disease (clinical symptoms confirmed by microscopical examination of discharges and by serum reaction).

(2) Isolation (exclusion from sexual contact and from the preparation or the serving of food during the early and active period of the disease).

(3) Immunization—none.

(4) Quarantine—none.

(5) Concurrent disinfection of discharges and of articles soiled therewith.

(6) Terminal disinfection—none.

(B) General measures.

(1) Education in matters of sexual hygiene, particularly as to the fact that continence in both sexes and at all ages is compatible with health and development.

(2) Provision for accurate and early diagnosis and treatment in hospitals and dispensaries of infected persons, with consideration for privacy of records and provisions for following cases until cured.

(3) Repression of prostitution by use of the police power and control of use of houses and apartments.

(4) Restriction of the sale of alcoholic beverages.

(5) Restriction of advertising of services or medicines for treatment of sex diseases.

(6) Abandonment of the use in common of towels, cups, toilet articles and eating utensils.

(7) Exclusion of persons in the communicable stage of the disease from participation in the preparing and serving of food.

(8) Advice regarding personal prophylaxis to those who expose themselves to opportunity to infection.

Some victims of syphilis are entirely unconscious of the fact that they have been infected until after serious lesions have developed. Others discover the existence of the disease early, but are led astray by advertisements of proprietary remedies. In the absence of disturbing symptoms some refuse to take adequate treatment from their physicians, only to develop later characteristic lesions in the nervous system.

Recent work has led students of the disease to believe that insufficient treatment in the early stages of the disease may render a patient more liable to the subsequent development of nervous lesions than if he had received no treatment at all. Anti-syphilitic treatment should be intensively applied as soon as possible after infection, should be continued for years, and should be as vigorous as the constitution of the patient will permit of.

Acute poliomyelitis (infantile paralysis) and acute cerebrospinal fever (cerebrospinal meningitis) are much less common diseases than syphilis. Sporadic cases are encountered here and there, but the main occurrence of these diseases is in epidemics. They are less contagious maladies than are most other epidemic diseases; in other words, in the general population there are more people who are immune from these diseases.

Cerebrospinal fever is due to infection with the meningococcus. The portal of entry into the body for the germ

is the mucous membrane of the respiratory tract. The fact that healthy people may carry the germs about in their mucous membranes and pass them on to other people makes the public-health control of the disease very difficult. The most important preventive measures are (1) the early recognition of the disease and (2) the early institution of treatment by means of the serum. A preventive vaccine has also been made, but its use would scarcely seem justifiable except during epidemics.

Acute poliomyelitis (infantile paralysis) is due to an organism so small that it can pass through the pores of a porcelain filter. It seems probable that the chief portal of infection for the virus of this disease also is the respiratory mucous membrane. Healthy carriers occur and help to spread the disease; moreover, there are many mild and abortive cases, some of which doubtless pass unrecognized. Our scientific knowledge of acute poliomyelitis is less satisfactorily developed than that concerning cerebrospinal fever; the methods of prevention are, accordingly, even less definitely indicated.

During the past few years encephalitis lethargica (sleeping sickness) has attained important proportions. We have, unfortunately, no exact knowledge of its cause or of satisfactory methods of protection against it. It seems probable, however, that the epidemiological factors concerned are not unlike those that hold for poliomyelitis. In planning preventive campaigns against either disease the dangers of contact infection and of spread by healthy carriers should be kept in mind.

Degenerative changes in the nervous system secondary to arterial diseases are practically inevitable, at least to some extent, in all who attain to advanced age. There are probably but few, if any, octogenarians who do not exhibit at least some signs of mental impairment. Failure of the capacity of memory for recent events is a part of the process of growing old. From the standpoint of prophylaxis it

should be our aim to prevent, as far as possible, the premature development of senile changes in the brain and to ward off also the arterial changes that are so often responsible for fulminant types of cerebral accidents occurring at comparatively early ages.

The factors concerned in the causation of degenerative arterial changes and the methods of controlling them have already been considered in a preceding chapter. They are so important, however, for the welfare of the nervous system that it would seem worth while to epitomize them here in a somewhat different form.

1. The importance of early training, especially as to proper values in life and in the details of hygienic living, can scarcely be overemphasized. If every young person could be trained to work "smoothly" with little or no friction and could be taught the virtues of suitable relaxation, of the cultivation of interests outside one's regular work and of vacations at regular times through the year, much could be done to prevent the early onset of arterial disease and to ward off nervous sequels.

2. Regular medical examinations for prophylactic purposes should become common practice. Unfortunately, up to recently, such periodic health examinations have been resorted to almost solely by those who were worried about their own health. It would, of course, be unwise to encourage introspective tendencies in those of psycho-neurotic trend. If, however, resort to regular health examinations were to become a universal custom, recognized as "the thing to do," the objection on the ground that the development of morbid hypochondriacal ideas might be encouraged would fall away.

3. Medical examiners should not forget the importance of inquiring into the types of constitutions of those they advise. Attention should be paid especially to those constitutional features that point to a predisposition either of the nervous system or of the vascular system to disease. The

value for prophylaxis of special advise based upon such special knowledge must be apparent to every one.

4. Dietetic-hygienic regimens suited to the constitutional needs and to environmental situations should be adhered to.

5. Potentially harmful extraneous poisons should be sedulously avoided.

6. The public should be thoroughly educated in regard to the care of infections, even of the milder sort. Every acute infection, even a "common cold," should be considered seriously, should be promptly treated, and should be watched through convalescence to complete recovery. The search for and eradication of foci of chronic infection will go far toward preventing the chronic intoxications that lead to some of the degenerative diseases of the nervous and vascular systems.

Interest in the prevention of degenerative diseases of the nervous system secondary to vascular changes may not be aroused until after the arteriosclerosis of the cerebral vessels has already become manifest. The general manner of living that should be adhered to by such patients has already been set forth, but the details must of course be determined for each patient by the physician in charge. Generally speaking, it is not wise to stop the patient's work entirely, especially if that work do not involve great physical strain, great anxiety, worry, or undue application. It may be well in certain instances to change the details of the work; thus, a lawyer may be advised to give up court work, which he has felt to be a great strain upon him, although it interested him immensely, and to confine his activities strictly to office work. Rest in the recumbent position for an hour after the mid-day meal should be considered an essential part of the regime in addition to eight or nine hours spent in bed each night. Hobbies, relaxations, and vacations are more important for the hypertensive nervous patient than for most others. Sudden and violent physical exertion should be avoided and the emotional life should be as calm as possible.

Here the physician and the daily associates of the patient have the rather delicate task of curbing one whose general tendency it is to overdo, while at the same time they avoid giving him the feeling that he is too much under surveillance or that he is regarded as a chronic invalid. Among the commoner requirements of a good regimen for patients of the type here under consideration are (1) moderate work, (2) rest in the middle of the day, (3) mild open-air exercise (like golf), (4) a bland diet with restriction of the intake of protein food, (5) restriction or prohibition of the use of alcohol, tobacco, and coffee, and (6) longer and more frequent vacations than are necessary for one in perfect health.

Since we know practically nothing of the causes of tumors of the central nervous system, we are quite helpless in preventing their development. The early recognition of the existence of a tumor and the speedy resort to ameliorative or curative surgical intervention may, however, be most advantageous. Even when a brain tumor cannot be localized or removed, blindness (degeneration of the optic nerves) may be avoided or postponed by a timely decompression operation.

Our newer knowledge of the degenerative diseases of the nervous system, due to metabolic defects, is full of hygienic lessons. Since beri beri can be prevented by giving a varied diet rich in vitamines, it may be that there are other degenerative diseases of the nervous system which would be less likely to develop if the diet were adequate. Indeed, it appears to have been demonstrated that pellagra may be prevented by a full and varied diet. The prevention of diabetes mellitus and of its nervous complications will be considered more fully in a subsequent section.

Since the cause of pernicious anæmia is still unknown, we are ignorant also of means to prevent its development. There is some evidence that heredity plays an important rôle in the origin of the disease. The malady is fairly wide-

spread, and many physicians are interested in it. It is possible that within the next few years we may have gained some knowledge that will make prophylaxis effectual. Meanwhile our reliance must be placed upon general hygienic measures for its prevention.

CHAPTER XIX

DEGENERATIVE CONDITIONS OF THE LOCOMOTOR APPARATUS, THE BONES, THE JOINTS, AND THE MUSCLES

Bone is living tissue just as other tissues are living, but it is relatively inactive tissue. It contains a large proportion of mineral constituents (especially of phosphates and carbonates of calcium and of magnesium), which give it its characteristic and useful rigidity. Tiny canals permeate the bony substance; in them are contained small bone cells and their processes, blood vessels, and nerves. In the interior of the bones is the bone marrow or medulla; in some of the bones (flat bones, vertebræ, ribs) the marrow consists of blood-forming tissue, but in the long bones (in adult life) it consists chiefly of fat. The surface of each bone is covered by a dense fibrous layer called the periosteum.

Cartilage is a somewhat different type of tissue; though it closely resembles bone, it is softer, containing less mineral matter. Many bones are first laid down as cartilage and later undergo osseous transformation. Growth of a long bone in childhood and youth occurs through the growth of the cartilage at each end of the bone, the newly formed tissue being quickly converted into bone. Cartilage covers the ends of the bones and thus enters into the structure of the joints.

Degenerative Conditions Affecting the Bones.—Some of the congenital anomalies of bony structures are of interest in connection with a general discussion of the degenerative diseases. These anomalies may depend upon excessive formation (for example, an extra rib) or of defective formation of parts (as in the so-called spina bifida, a defect in the

verterbral column with the formation of a cleft through which the meninges and perhaps even the spinal cord may protrude). Minor anomalies of both kinds, which do not give rise to unpleasant symptoms or indeed to any disturbance, are fairly common. An extra rib in the neck, articulating with the lowest cervical vertebra, may compress those nerves that are grouped together in the neck to form the so-called brachial plexus; through such pressure upon the nerve tissues degenerative changes may be set up in them, with the production of symptoms (pain in the arm, paralysis, and atrophy of some of the muscles, and sometimes sensory disturbances other than pain).

Among the more purely toxic degenerative diseases of the bones we may mention: (1) osteoporosis (bone atrophy), (2) phosphorus necrosis, (3) rickets, (4) achondroplasia, (5) unusual fragility of bone, (6) osteomalacia (softening of bone), and (7) Paget's disease.

Atrophy of the bone (osteoporosis) may occur under a variety of influences, especially those of disuse and of advancing age. When for any reason the muscles of a part are kept at rest for some time the bones beneath these muscles lose much of their calcium and become abnormally transparent on X-ray examination. After fractures of bone and after the development of diseases of the joints causing partial fixation of an extremity, such an atrophy of the bone from disuse occurs. Though the bones of the aged contain large amounts of calcium, they are relatively porous, and are in general thinner and much more easily fractured than are the bones of young people.

In phosphorus poisoning, an extensive destruction of the bony tissue may occur. In this phosphorus necrosis there is a special predilection of the jaw bone.

Rickets is a disease of the bones often met with in children during the first two years of life, when the skeleton is developing very rapidly. The exact cause, the defect of metabolism, in this disease is not yet known. There would, however, appear to be a distinct hereditary factor in its causa-

tion, and on the environmental side bad hygienic conditions (impure air, poor food, lack of sunlight and exercise) are also believed to be of importance. Though the disease is commoner among the poor, it may be met with in well-to-do families. The skeletal changes are the most important features of the disease. These consist of (1) softening of the bone, leading to abnormal curvatures, (2) loss of bony substance, (3) thickenings of the bones, and (4) disturbances to the longitudinal growth of the bone. Among the skeletal scars of rickets that may persist throughout life are changes in the shape of the thorax, curvature of the spine, bow-legs or knock-knees, flat feet, and deformations of the bony pelvis that in women may be of the greatest importance by interfering with normal childbirth.

Achondroplasia is a rare, hereditary disturbance of the skeleton, characterized by very short limbs, trident-shaped hands, and usually some enlargement of the head, though the trunk may be normally developed. The subjects of this disease though dwarfs, are usually of normal intelligence.

Osteomalacia is a disease in which the bones become softened and in some other ways resemble those of rickets. Women in the reproductive age are most often affected and it is relatively common during the puerperium—that is to say, just after childbirth. In this disease there is a marked diminution of all the mineral constituents of the bones. The bones as a consequence become soft and those subjected to the most pressure, for example the vertebræ and the pelvic bones, may be very much deformed. The disease is, fortunately, rare. Its cause is not yet definitely known. Some physicians have suggested that the glands of internal secretion are at fault and point to the fact that it occurs usually during the reproductive age in women and that the removal of both ovaries has not infrequently resulted in improvement or recovery from the bone disease. However, osteomalacia can occur independently of pregnancy and of the puerperal period; it has even been described as occurring also in men. It is amenable to treatment by means of a proper dietetic and

hygienic regimen with the administration of phosphorus and cod-liver oil.

Paget's disease (osteitis deformans; senile pseudo-rickets) is a disease of the bones that usually begins after middle life, progresses very slowly, and is characterized at first by softening of the bones and later by much new bone formation, with the production of characteristic deformities (marked enlargement of the skull, triangular face, marked gradual bowing of the spinal column, and marked bowing of the legs forward and lateralward). This disease also may be encountered as a family disease. It is associated in almost all cases with an extensive arteriosclerotic process.

Infections of bones may lead to deformities. Thus, tuberculosis of the spine may cause destruction of the vertebræ and pressure upon the spinal cord, with resultant degenera tive changes in the nerves, as already mentioned.

The Joints.—The ends of the bones, where they meet to form joints, are covered with a layer of cartilage. This in turn is covered over by the lining membrane of the joint (the synovial membrane). The whole is surrounded by the joint capsule, which consists of dense fibrous tissue and is strengthened by the ligaments that pass from one bone to the other and by tendons that serve as the attachments of the muscles to the bones. Overlying some of the joints and in some cases connected with them are sacs lined by synovial membrane and containing a clear fluid similar to that within the joint cavity itself. These little sacs or pads are called bursæ.

Joints may be congenitally diseased, as in certain forms of club-foot, of flat foot, and of dislocation of the hip; they may be diseased by reason of hemorrhage into the joints, such as occurs in some blood diseases; or, again, joint lesions may occur as a result of diseases of the nervous system. The most important, however, of all the joint diseases, from our present standpoint, are those due to inflammation. Inflammatory disease of a joint is called arthritis and, as is the case with other inflammation, an arthritis may be acute or chronic.

Acute arthritis.—One of the most important varieties of acute arthritis is acute rheumatic fever, a disease that often attacks children and younger people. Its importance lies chiefly in the fact that it attacks not only the joints, but in a large proportion of the cases the heart also. We have already mentioned how very important acute rheumatic fever is for the etiology of heart diseases. As to the joints themselves in this acute disease, they are very painful and are subject to recurrent attacks, but they usually recover completely without residue.

Other forms of acute arthritis occur when germs are present in the blood, for example in septicæmia, sometimes in gonorrhœa, and occasionally in typhoid fever, in dysentery, in syphilis, and in certain of the acute eruptive fevers. Gonorrhœal infections of the joints are apt to leave some residue. Should pus form in the joints, as sometimes happens in septic infections, the residual changes in the joints, after recovery, are usually pronounced.

Much more common and much more important from the standpoint of degeneration of the locomotor apparatus are the cases of *chronic arthritis*. This may be conveniently subdivided as follows: (1) true chronic gouty arthritis; (2) primary hypertrophic osteoarthritis; (3) secondary chronic infectious arthritis, following various types of bacterial invasion; (4) so-called primary chronic progressive polyarthritis (though this should probably be placed as a special member in the preceding group).

All observers are united in considering gouty arthritis to be due to a metabolic disturbance. We have already referred to the basis of gout as a constitutional inability to metabolize (or properly to take care of) the purin substances. We might speak of a gouty person as a physiological variant from the usual average normal of the species or race, for the tendency to gout is distinctly inheritable. The exciting factors of gouty attacks are overeating, indulgence in alcoholic beverages, especially the wines and malt liquors, a sedentary

occupation with lack of out-of-door exercise, worry, sudden mental shocks, or even a slight injury or accident.

The purin bodies are derived from nucleo-proteins of the food and of the tissues. A certain amount must be taken care of daily, whether the person eats substances containing them or not. This is the so-called endogenous purin component (derived from the patient's own body) as opposed to the exogenous component that is taken in with the food. When the body cannot take care of these purin substances they tend to accumulate in the blood, and their end product, uric acid, can be demonstrated there in increased amounts. In gouty patients there are deposits of salts of uric acid in and about some of the joints, especially in the cartilagenous portion, and in attacks of gout there occurs a reactive inflammation about these local deposits. The first joint of the great toe is most frequently involved, next in frequency the ankles, then the knees, and the small joints of the hands and wrists. The acute arthritis of gout is exquisitely painful and the pain is apt to be very much worse at night. The acute phase of an attack may last for a week or ten days; three or four such attacks may occur during a year. After attacks of gout have recurred at intervals for years many of the joints may have become permanently swollen and deformed by tophi. Arterial degeneration is a common accompaniment of gout.

Concerning the origin of hypertrophic osteoarthritis, there is less unanimity of opinion. Some consider it also to be due to a metabolic disturbance somewhat allied to gout. Others think it is more closely related to the infectious types of arthritis. It affects, as a rule, one or only a few of the joints, and the large joints, hips, shoulders, or knees are involved rather than the smaller ones. Men are more frequently attacked than women and the cases are most frequently met with in advanced life. The joint changes are characterized especially by the production of new bone with formation of projections (exostoses). In the early stages there may be seen in the X-ray pictures tiny spicules or out-

growths of new bone along the edges of the articulating surfaces. Later on these bony outgrowths may become very large, so that they can be easily felt by the examining finger. Minor changes of this type are so frequent in X-ray pictures of bones and joints of older people that they are considered almost a normal accompaniment of advancing age. The roentgenologist often uses this feature as a means of estimating the age of the patient whose X-ray picture is before him. Certain types of hypertrophic osteoarthritis have been given special names; for example, this disease of the hip in old people is called "malum coxae senile," and when it attacks the spine it is called "spondylitis deformans."

The causes of hypertrophic osteoarthritis are obscure. The predisposing factors in this group are not at all known. Exciting factors include static disturbances (that is, disturbance in the physics of the limb of which the joint is a part). If one joint of a limb be diseased, or if a muscle be strained, additional stress is thrown upon the other structures of that limb. The static disturbances caused by general obesity may often be of importance for the origin of joint diseases, especially those of the lower extremities, as, for example, in the production of flat feet. It is difficult to judge of the influence of trauma in the production of osteoarthritis, for we know that marked changes in the joints, as determined by X-ray examinations, may exist for some time before any symptoms are noticed. The symptoms may be produced (or inaugurated) by an injury, like a sudden wrench or strain, and it is natural for patients to attribute the origin of the malady as a whole to the influence that is first provocative of symptoms.

Most important because most frequently encountered and most crippling are the cases of infectious arthritis. These form a large group, embracing many different types of joint diseases, some of them characterized chiefly by changes in the soft parts of the joints, others by erosion of the cartilage and of the bone, and by formation of new bone in and around the joints. One joint, a few, or many of the joints of the

body may be involved. Sometimes the disease occurs in a series of more or less acute attacks, each of several weeks' duration, and in the interval between attacks the patient may feel quite well and suffer from but little joint disability. In other cases, the changes in the joint symptoms occur very slowly, and the disease may last for years; there may then be a gradual improvement or the arthritis may persist as a crippling factor throughout the remainder of the patient's life.

There is now a general consensus of opinion among physicians that in these cases of infectious arthritis, focal areas of infection in the tonsils, in the gums, about the roots of the teeth, in the paranasal sinuses, in the gastro-intestinal apparatus, in the urogenital tract, or in the gallbladder represent a primary process to which the arthritis is secondary. Some of the cases of infectious arthritis respond favorably to treatment by eradication of areas of infection and by general upbuilding; but many of the cases are very tedious and resist the most carefully formed plans of treatment. An ounce of prevention is in this truly terrible disease certainly worth many pounds of attempted cure.

Muscles.—Diseases of the muscles are closely allied to diseases of the bones and of the joints.

Inflammation of the muscles is known as *myositis;* it may occur from the same causes as are productive of arthritis. There is one rather interesting chronic degenerative type of myositis, called ossifying myositis, in which the degenerated muscle tissue becomes saturated with lime salts and may after a while even be converted into bone. Some extreme examples of this disease have been shown in side shows as "the ossified man" or "the man who is turning slowly to stone."

Prevention of Chronic Degenerative Conditions of Bones, Joints, and Muscles.—In the prevention of the chronic, deforming, crippling lesions of the locomotor apparatus the most rewarding efforts are doubtless those directed toward the prevention and cure of infections, though

something can be done also by combating the metabolic disturbances that lead to joint changes.

Gout is a comparatively rare disease in this country, and, especially in contrast with other types of chronic arthritis, it is but seldom seen. Those who consider hypertrophic osteoarthritis a metabolic disturbance usually prohibit certain articles of diet, such as acid fruits and vegetables like tomatoes; but such prohibitions are of doubtful importance and apparently without any scientific basis. Fancies about uric acid were very common at one time, and many people are still inclined to attribute many ills and fancied ills to abnormalities of uric-acid metabolism, even those that are far removed from any of the manifestations of real gout.

The attack from the infectious side can be made effective only by systematic examinations at more or less regular intervals. This is already a fairly widespread custom in regard to dental work, although, unfortunately, dentists do not always seek for foci of infection when patients apply to them for examination. A regular general physical examination once a year, together with the proper suggestions as to how to keep well, based upon the findings in such examinations, might do a great deal toward the prevention of infectious arthritis as it would toward the prevention of many other degenerative conditions.

A person with a gouty tendency, or one who has reason from his family history to belive that he might develop such a tendency, should be given explicit directions how to live. He should avoid absolutely all alcoholic beverages, and he should particularly avoid overeating. His diet should be light, sufficiently nutritious, and it should not include those substance that contain a large amount of purin bodies (sweetbreads, liver, kidneys, and brain). He should take much physical exercise out-of-doors. More than most people he may profit by judicious mental hygiene, and this notwithstanding the old adage that "more wise men than fools have the gout."

Primary diseases of bones are relatively uncommon and

cannot compare with those of the joints as menaces to the health of people of advancing years. Heredity is probably an important factor in most of the chronic bone diseases of later life. Osteomalacia, as we have already said, is most common in women and especially during the child-bearing period; adequate prepartum and postpartum observation by the obstetrician is of the greatest importance in avoiding ills incident to this time of life. Some observers are inclined to attribute osteomalacia to the lack of certain vitamins in the diet, and others are inclined to consider it as due to infectious processes. Dietetic and anti-infectious measures may accordingly be helpful in preventing osteomalacia. Certainly, a well-balanced diet is indicated for the pregnant woman as well as for the woman during the puerperium; it should contain leafy green vegetables (relatively rich in mineral constituents), milk and milk products, and fruits or fruit juices in addition to the ordinary proteins, carbohydrates, and fats.

CHAPTER XX

DEGENERATIVE DISEASES OF THE ENDOCRINE GLANDS

In a preceding chapter (Chapter XII) we have indicated the bearing that abnormalities of the glands of internal secretion may have in bringing about degenerative states in other organs or tissues. In this chapter we shall consider briefly some of the degenerative conditions that may affect the glands themselves.

The more important of the endocrine glands (glands of internal secretion; ductless glands) are the thyroid gland, the parathyroid glands, the hypophysis cerebri or pituitary body, the gonads or sex glands, the suprarenal glands, and the islands of Langerhans in the pancreas. The secretions from these glands are absorbed into the blood and are carried by the blood stream to other parts of the body.

Degenerative states may affect any of these glands with the production of more or less characteristic symptoms, due to a lack of the usual secretion of the gland involved. We shall concern ourselves here with disorders of the thyroid gland and with those of the islands of Langerhans of the pancreas (diabetes mellitus) for two reasons—(1) because they are important and widespread diseases and (2) because there is some definite scientific basis for prophylactic measures against them.

The Thyroid.—The thyroid gland is situated at the base of the neck, in front of and partially surrounding the windpipe just below the larynx (Adam's apple).

By microscopical study it may be seen that the gland is composed of many minute vesicles, each one lined by a single layer of epithelial cells and filled with a homogenous semi-

fluid material (colloid). Between the alveoli there is a small amount of connective tissue in which may be found the blood vessels and the nerves. The thyroid is very vascular —that is to say, it contains a great many blood vessels and through its nerves it is intimately connected with the autonomic nervous system. In the normal gland the small vesicles, or alveoli, as they are often called, are of approximately uniform size and their lining membrane is even and regular.

It has been known for some time that iodin is a very important constituent of the thyroid gland and that extracts of the gland are potent in proportion usually to the amount of iodin that they contain. Comparatively recently, Kendall has isolated from the thyroid gland an active principle which he called thyroxin, the iodin content of which is 65 per cent.

Through its internal secretion the thyroid exercises a profound influence upon the rest of the body, especially upon the growth of the skeleton, upon the development of most of the tissues, including those of the central nervous system, upon the sexual life of the individual and the development of the secondary sex characteristics, and finally upon the general metabolism which it controls and regulates.

Diseases of the Thyroid Gland.—It is quite common to see a moderate and a temporary enlargement of the thyroid in young girls at the time of puberty and in women during pregnancy. These enlargements are not ordinarily spoken of as goiter. Any chronic enlargement of the thyroid gland constitutes a goiter.

The commonest form of goiter is the so-called simple goiter or endemic goiter, so called because it occurs in many people of a more or less restricted area and is relatively uncommon in other regions. Goiter appears to be endemic particularly in mountainous regions and in territories remote from the seacoast. For example, goiter is endemic in America in the region about the Great Lakes and in the Rocky Mountains; in Europe the most important center is in the Alps, in Switzerland and in the Austrian Tyrol; and in Asia in the Himalayas. It is not, however, invariably

associated with mountainous regions, for it occurs in America on the Pacific coast and on other coastal plains in other parts of the world.

Wherever goiter is endemic there are also found comparatively large numbers of cretins whose retarded and imperfect physical and mental development is due to a deficiency of the thyroid gland. Cases of deaf-mutism and of idiocy without all the characteristic marks of the cretin are also more numerous in regions where goiter is endemic. Further, cases of hypothyroidism among adults are more common in goiterous regions and, in the opinion of many observers, exophthalmic goiter is also more prevalent in regions where endemic goiter prevails.

A simple goiter of moderate size may cause no symptoms whatever other than the disfigurement. After attaining a larger size, serious symptoms may be brought about by pressure of the enlarged gland upon the surrounding tissues. Various pathological degenerative changes are common in large goiters. Some of the enlarge thyroids become insufficient from a functional standpoint and the patient suffers from symptoms of hypothyroidism, or myxedema. In some cases the goiter becomes toxic and the individual with such a goiter shows evidence of a disease that is known as exophthalmic goiter or of a toxic adenoma.

The Cause of Goiter.—The etiology of goiter is at present only imperfectly understood, but there have been demonstrated interesting facts that have a bearing upon it. For a long time goiter has been associated in the minds of the physician and of the layman with bad water. In countries where goiter is endemic goiterous wells, goiterous springs, and goiterous lakes are pointed out. It has been shown in Switzerland that those waters particularly associated with development of goiter in people who drink of them contain comparatively large numbers of bacteria. McCarrison in India was convinced that a polluted water supply was the most important cause of goiter. He filtered specimens of polluted water through a porcelain filter,

collected the material that did not pass through the filter, and fed this deposit to thirty-six men, ten of whom developed goiter and five more showed a transient swelling of the thyroid gland. As a further experiment he boiled some of this material and fed it to a group of thirty-one men, none of whom developed goiter.

Goiter is not uncommon in other animals besides man. It occurs, for example, in dogs, in horses, in sheep, and in fish, and in some of these forms of animal life it has been studied thoroughly. The classical studies of Marine on the brook trout showed that the changes in the thyroid gland which constitute goiter in these fish were noted particularly in those tanks where the fish were most crowded and where the water was most polluted. He found that goiter could be prevented by furnishing the fish a fresh and clean water supply or by adding iodin to the water.

There are at present a number of different hypotheses as to the causation of goiter. First, that it is due to a micro-organism, the exact nature of which is unknown; second, that it is a metabolic disturbance, brought about by unsanitary conditions; according to this conception, the metabolism of the body is disturbed by these unsanitary conditions and the enlargement of the thyroid gland is a compensatory mechanism by which the metabolic derangement is combatted. The thyroid enlargement is immediately determined by a relative or an absolute deficiency of iodin. The deficiency may result from an increased need of the organism for iodin (as in pregnancy), from an interference with the absorption and the utilization of the normal iodin intake in the food, or from an actual deprivation of iodin. According to Marine, when the store of iodin in the thyroid has fallen below 0.1 per cent, there occur increased vascularity of the gland and increase in the size and number of the thyroid cells.

The prevention of Goiter.—Not every one in the regions where goiter is endemic contracts the disease, although McCarrison states that in certain villages of the Himalayas

very few of the inhabitants escape. There is, then, a certain constitutional predisposition to goiter shown by certain individuals. Girls and women are much more prone to the development of exophthalmic goiter than are men. Those people who have a family history of goiter should exercise particular care in the prophylaxis of the disease.

There is now ample evidence of the value of iodin in the prevention of goiter.

Marine's observations on brook trout have already been mentioned. Goiter among the sheep was said to be a serious menace to the sheep-raising industry in the Northwest until it was found that the goiter did not occur when the salt fed to the sheep contained iodin as an impurity. Furthermore, Marine has demonstrated by his work with the school children of Cleveland that goiter can be prevented in a similar way in human beings by the administration of small doses of iodin once or twice a year.

McCarrison believes that the three periods of life at which simple goiter most commonly develops are (1) during fœtal life, (2) during adolescence, and (3) during pregnancy and lactation. It is at these periods particularly that prophylactic measures should be adopted. There would, however, seem to be no objection to the general use of iodin, particularly in localities where goiter is of frequent occurrence.

The iodin may be administered in different ways. Marine suggests 15 to 30 cc. of the syrup of hydriodic acid to be given in .5 to 1.0 cc. doses daily and repeated each spring and autumn. Where the prevention of goiter is adopted as a public-health measure the cheaper salts of iodin, as for example sodium iodid, may be used with equally good results. In some cities iodin is added in small amounts to the drinking water at the source of supply or of storage. Another suggestion is that sodium or potassium iodid be added to the salt used in the home for cooking and as a condiment on the table. One-quarter to one-half a teaspoonful of sodium iodid added to a pound of salt and thoroughly

mixed with it would be an ample supply. It has been suggested that the refiners and distributors of salt add the iodin before it is sold to the consumer.

After a goiter has attained a large size and pressure symptoms have become manifest, the possibly serious dangers can be obviated only by surgical means.

In cases with deficient functioning of the thyroid gland (cretins and adult hypothyroidism or myxedema) very strikingly beneficial results are usually obtained by the administration of proper doses of thyroid extract. The symptoms may usually be entirely relieved in adult hypothyroidism and the development and health of the cretins may also be materially improved.

Degenerative States Affecting the Internal Secretion of the Pancreas

Diabetes mellitus is a condition characterized by an inability on the part of the body to burn or to store up the carbohydrates (sugars and starches). It may exist in any degree from a very mild one, in which the defect, though demonstrable, is very slight to very severe grades in which the ability to metabolize carbohydrates is entirely lost.

Normally the starches and sugars of the food are split up by the intestinal juices into the simplest forms of sugar (monosaccharides—glucose, galactose, levulose) which are absorbed and pass into the portal circulation. Most of the sugars are taken from the portal blood by the liver and stored in the liver as glycogen. The glycogen of the liver is easily broken down again into glucose and given off into the blood stream as demand is made upon it by the tissues as a source of energy. In this way the amount of glucose in the circulating blood is maintained at an approximately constant level (0.08–0.12 per cent).

When very large amounts of sugar or candy or syrup are eaten at one time by a normal person the storage facilities are overtaxed, the amount of sugar in the blood of the systemic circulation becomes unusually high, and when the

blood sugar reaches a certain height (say 0.16–0.2 per cent) some of the sugar passes through the kidneys and may be demonstrated in the urine. This is known as alimentary glycosuria.

In diabetes mellitus the tissues are unable to utilize sugar in the normal way or to the usual extent. The sugar in the blood is increased (hyperglycæmia) and consequently sugar appears in the urine (glycosuria). With the hyperglycæmia there occurs increased thirst, and following the ingestion of a large amount of water there is the passage of a large amount of urine (polyuria). There is a loss of energy in the warming of the excessive quantity of fluid taken into the body, but the energy loss is particularly severe in the steady waste of the sugar fuel. The carbohydrates are the most important source of energy under normal conditions. About 60 per cent of the caloric value of a normal diet should consist of carbohydrates. Hence the loss to the body in severe diabetes is very great. As the carbohydrates pass through the body without being utilized, the necessary energy must be supplied by the combustion of the proteins and of the fats of the food and of the tissues. The proteins are burned with no great difficulty, but in the absence of sufficient glucose, fats are imperfectly consumed. This imperfect combustion of fats results in the formation of toxic substances (betaoxybutyric acid) that may accumulate in the body and produce an acidosis, the most serious of the complications of diabetes.

It is now generally believed that diabetes mellitus is due to the absence (or insufficiency) of the normal internal secretion of the pancreas and this internal secretion (insulin) is a product of the cells of the islets of Langerhans.

Causes of Diabetes Mellitus.—*Heredity* is an important factor. There are records of the occurrence of diabetes mellitus in many members of the same family. Naunyn obtained a family history of the disease in 35 out of 201 private cases, but in only 7 of 157 hospital cases. The better known the family history is to the patient the greater

the likelihood of obtaining a positive history of an hereditary factor.

Certain races, notable the Hebrews and the Hindus, seem especially prone to the development of diabetes, but it may be that this tendency, in part at least, is due to environmental factors, particularly to super-alimentation and the resulting obesity. It is interesting, however, that diabetes is said to be rare among the Japanese, whose diet contains a very large proportion of carbohydrates.

Sometimes the tendency to the disease seems to be very strong, the patient develops diabetes early in life, and these juvenile cases are as a rule very severe. Usually, however, the patient seems to be normal in respect to his carbohydrate metabolism during the first three or four decades and the disease develops in later life if the environmental factors (overeating, obesity, infection) have been such as to put an unusual strain upon the insulin production of the pancreas. The onset of diabetes occurs most commonly between the fortieth and sixtieth years of life.

The pathological personal variant, one of whose "weak points" is in the metabolism of carbohydrates and who therefore is in danger of the development of diabetes, may also contain in his chromosomes determiners of other endocrine anomalies (thyroid disease—hypophyseal disease) and may have a constitutional tendency toward obesity.

The environmental factors of importance for the development of diabetes mellitus include all the agencies that may damage the structure or the function of the islands of Langerhans in the pancreas.

As we have mentioned in a preceding section, disease of the pancreas may result from lesions of the gallbladder and of the bile ducts, from direct infection through the blood stream, and from circulatory disturbances (arteriosclerosis and passive congestion incident to cirrhosis of the liver). In the pancreatic lesion secondary to gallstones or to infections of the biliary tract the islands of Langerhans usually escape material damage, and diabetes is not

a common sequel to such lesions. Changes in the pancreas due to arteriosclerosis or secondary to cirrhosis of the liver are more diffuse and more frequently associated with damage to the islands.

The effect of bacterial infections as causes of diabetes has been a subject of discussion for many years. It is universally admitted that infections very markedly diminish the carbohydrate tolerance of a person who has already developed diabetes, and it seems highly probable that they may act as exciting causes of the condition in those with a definite constitutional tendency toward its development.

Of all the conditions that are associated with the development of diabetes and that may be considered in large part environmental, that of obesity or overnutrition is the most important. This factor has been particularly emphasized by Joslin.[1] In his analysis of the statistics of 1,000 cases of diabetes he found that the maximal weights of only 10 per cent of the patients were below the standard-weight zone, 15 per cent came within this zone, and 75 per cent were above it. The factor of overnutrition is much less important in the development of diabetes in youthful individuals than it is in those above the age of twenty years. In Joslin's opinion the liability to diabetes is at least twice, and at some ages forty times, as great in the person who is overweight as it is in those who are of normal nutrition or underweight. "For the prevention of more than half of the cases of diabetes in this country, no radical undernutrition is necessary; the individual is simply asked to maintain the weight of his average fellow man."

The Prevention of Diabetes Mellitus.—Statistics for the last thirty years show a marked increase in the incidence of this disease, but the increase is certainly in part due to the fact that more examinations of the urine are made and more cases recognized. Joslin estimates that there are

[1] E. P. Joslin, "The Prevention of Diabetes Mellitus," *Journ. Am. Med. Assoc.*, Chicago, 1921, vol. 76, p. 79.

probably more than half a million diabetics in the United States.

The evidence of the importance of heredity need not be discouraging in the campaign for the prevention of diabetes. Probably those cases that develop early in life cannot be prevented, save by eugenical measures, but the disease is fortunately rare in childhood. Those with a family history of the disease should be definitely put on their guard and their dietetic—hygienic regimens should be arranged with a view to keeping the state of nutrition below the general average level. Allen demonstrated a few years ago the value of low nutrition in the treatment of diabetes and, if this principle is effective in treatment, much more may be expected of it in prophylaxis. In a person with normal metabolism the greater the supply of carbohydrate the more the body consumes; in a diabetic the greater the supply of carbohydrates beyond his limit of assimilation the less the body consumes not only relatively but actually. When it is overtaxed the capacity of the diseased individual definitely decreases. Presumably the same may be true for those who have a tendency toward the development of diabetes, but in whom it has not yet become apparent.

In the absence of a history of diabetes in the family we have no simple method of detecting those who may have a tendency toward the development of the disease. Occasional examinations of the urine would be helpful. One author has suggested that everyone should have the urine examined on each birthday. The more complicated methods of testing the carbohydrate metabolism are available for comparatively few people and are not ordinarily employed in the absence of some special indication. From the standpoint of the prevention of the disease it would be safer to assume with Joslin that every obese person past forty years of age is a potential diabetic.

As we have pointed out elsewhere in this book, the danger of diabetes is only one reason for the avoidance of obesity

in the second half of life, but it is an important one. Fortunately more and more physicians are becoming interested in pointing out to their obese patients the potential dangers attendant upon their obesity and in showing them how they may most easily and safely reduce their weight.

INDEX

A

Abdominal angina, 122
Acetone bodies, 31, 37
Achondroplasia, 25, 223, 224.—*See also* Bones, diseases of
Acidosis, 37, 99
Acids:
  betaoxybutyric, 238, 242
  carbolic, 169
  diacetic, 37
Acromegaly, 99
Adami, 32
Addison's disease, 99, 101
Adenoids, 88, 89, 159, 184, 185
Adenomata, toxic, 38, 99, 234.—*See also* Hypothyroidism
Adrenals, 100
Age, 123
Air:
  as a factor in euthenics, 62–67
  fresh, 33, 62, 63
  vitiated, 62, 63, 64, 65.—*See also* Ventilation
Albumin (*see* Bright's disease, Kidneys, Nephritis)
Alcohol, 13, 18, 31, 35, 37, 83, 93, 95, 106, 125, 130, 134, 145, 148, 163, 189, 208–209, 220
Alimentary tract, 78
Alkaloids, 181
Alternans, pulse, 152
Amalgamation:
  immigration as a factor in, 49
  racial, 49
Amblyopia, toxic, 95, 96
American Public Health Association, 215
Amino-acids, 68, 99
Ammonia, 69, 82
Amœba, 5
Amylase, 194
Anabolism, 35
Anæmia, 62, 99, 147, 213, 220
Aneurysm:
  aortic, 127, 147
  miliary, 120
  production of, 117
Angina pectoris, 153
Animals, heredity and development in, 9
Antivivisection, 56, 86
Aorta, 111, 112, 113, 126
Aortitis, syphilitic, 130
Apathy, 38
Aphasia:
  motor, 211
  temporary, 120
Aplasia, vascular, 101
Apoplexy, 16, 120, 127, 211
Appendix, inflamed, 40
Arachnoid, 198
Argon in atmosphere, 63
Arsenic, 35, 84, 89, 169, 180, 210
Arterial system, 15
Arteries:
  coronary, 118
  degeneration of, 37
  diseases of, 3, 111–135, 217, 218
  effects of infection upon, 25.—*See also* Arteriosclerosis
Arterioles, 103, 104, 121, 124, 147
Arteriosclerosis, 35, 37, 52, 89, 94, 96, 116, 135, 152, 170, 172, 196, 207, 210, 219, 239
Arthritis, 36, 37, 128, 225, 229, 230
Asepsis, 8

Association for the Prevention and Relief of Heart Disease, 157
Asthma:
bronchial, 35
cardiac, 154
Ataxia:
Friederich's, 13, 25
locomotor, 16
Atrophy, muscular, 25
"Auto-intoxication," 80

B

Bacillus:
Bulgarian, 80
tubercle, 12, 62.—*See also* Bacteria
"Back to the farm" movement, 65
Bacteria:
biological toxins from, 31
culture media, 75
destruction by stomach juice, 79
in atmosphere, 66
in bad air, 63
infection from, 125, 131, 145
in the blood stream, 34
in urine, 82
pyogenic, 61
removal by defecation, 78
Bacterial poisons, 85–97
Bacteriology:
Advent of, 3
development of, 8
Banting, 100
Bateson, 45
Bell, Dr. Alexander Graham, 26, 27
Benzol, 35
Beri beri, 74, 99, 213
Best, 100
Betaoxybutyric acid, 238, 242
Bile, 79, 178–184.—*See also* Biliousness
Biliousness, 182
Biology, 24
Biology of Death, The, 7 n.
Biometry, 53.—*See also* Statistics, vital
Birth, control, 49; rate, 49
"Black Hole of Calcutta," 62
Bladder, 83, 171, 173, 174, 204
Blind, congenitally, marriage of, 48
Blood pressure, 41, 103–136, 151
Blood vessels (*see* Arteries, Capillaries, Veins)
Body, temperature of, 32
Bones, diseases of, 14, 38, 186, 222–225, 229–231, 236
Bowels, 163
Bowman's capsule, 166, 167
Brain:
areas in, 201, 202
cortex of, 200, 209
degenerated fibers in, 200, 209, 213
diseases of, 3
disturbance in blood supply, 210
effect of arterial changes upon, 29
gray matter of, 198, 199, 212
hemispheres of, 200
injury to the, 201
lesions of, 202, 211
seat of nervous system, 39
softening of, 16
tumor on, 212
ventricles of, 198
wet, 209
white matter in, 198
Bright, Richard, 168
Bright's disease, 16, 37, 128, 155, 157
Bronchitis, 155, 160
Brown-Séquard, 101

C

Calcium, 69
Calculi, 99
Cannon, 40
Cantharides, 169
Capillaries, 111–113, 177
Capsule, Bowman's, 166, 167
Carbohydrates, 33, 68, 69, 70, 74, 180
Carbolic acid, 169

Carbon dioxide, 31, 35, 62, 63, 69, 116
Cardivascular system, 130
Carrel, 6
"Carrier, typhoid," 184
Catabolism, 35
Cavity, abdominal, 166
Cells:
  body, 7
  egg (*see* Ovum)
  fertilizing (*see* Spermatozoa)
  germ, 5–6, 10, 17, 18, 22, 23, 24, 30, 94
  soma, 5–6, 18, 24
Cerebrospinal fever, 56, 87, 216, 217.—*See also* Meningitis.
"Character, inheritance of acquired," 17
Chemical factors, 31, 33
Chemotherapy, improvement in, 9
Chicken pox, 60
Child labor, regulation of, 58
Chlorin, 69
Chloroform, 35, 180
Cholelithiasis, 183, 185.—*See also* Gallstones
Cholera, 34, 56, 190
Cholesterin, 180, 183
Chorea, 13, 143, 144, 157, 159; Huntington's, 25, 52, 204; Sydenham's, 25
Chromatin, 22
Chromosomes, 22
Churches, respiratory infections in, 67
Circulation, pulmonary, 111
Circulatory apparatus, structure and function of, 111–116; system, 94
Cirrhosis, atrophic, 188, 189, 191; hypertrophic, 188, 190–191
Cities, crowding in large, 57
Civilization, Greek, 34; Roman, 34
Claudication, intermittent, 96, 122
Clothing, protective, 97
Cocain, 210
"Cold, common," 88, 219
Colon, 79
Color blindness, 25
Conklin, E. G., 21 n., 31, 33
Consanguinity, 51
Constipation, 38, 73, 77, 80, 81, 94, 163, 176
Contagion, psychic, 61
Conveyances, respiratory infections in, 67
Convulsions, 172
Cord, spinal, 171
Cornea, arcus senilis of, 12
Coughing, 63, 67
Cowpox, 86
Creatinin, 69, 82, 101, 165
Cretin, 38
"Cro-Magnon man," 45

D

Dairy inspection, 58
Daltonism (*see* Color blindness)
Darwin, Charles, 47
Davenport, 25
Daylight, diffuse, 66
Deaf and dumg, marriage of, 48
Deaf-mutism, congenital, 51, 204
Death:
  accidental, 4
  causitive factors, 8
  from bacterial infection, 4
  from traumatic injury, 4
  natural, 5, 7
  rate in United States, 4
Defecation, 78
Defectives, segregation of, 49
"Deficiency diseases," 74
Degenerates, segregation of, 49
Degeneration, arterial, 226
Delirium tremens, 209
Dementia:
  paralytica, 207
  præcox, 51, 204
  senile, 121
Dentition, delayed, 38
Deterioration, mental, 207
Development, child's, psychic and social sides of, 60

de Vries, 19, 47, 48
Diabetes:
  insipidus, 25, 78, 83, 99
  mellitus, 25, 37, 72, 73, 74, 98, 99, 100, 122, 128, 132, 194, 197, 213, 220, 232, 237, 238
Diacetic acid, 37
Diarrhœa, 163
Diet, 34, 40, 68–77, 74, 131, 172, 175, 186, 220, 221, 238
Digestion, 69
Digestive system, 94
Diphtheria, 3, 9, 25, 60, 85, 86, 91, 159, 169, 172
Disease:
  Addison's, 99, 101
  arterial, 3, 111–135, 217, 218
  Bright's, 16, 37, 128, 155, 157, 168
  "common cold," 88, 219
  conveyance of, 33
  deaths from, 157
  deficiency, 34, 74
  hypophyseal, 239
  immunity from, 56
  infectious, 3
  of bones, 14, 38, 186, 222–225, 231, 236
  of brain, 3
  of endocrine glands, 232–242
  of heart, 32, 95, 136–164, 195
  of joints, 225–229
  of kidneys, 31, 165–177
  of liver, 185, 193–239
  of nervous system, 198, 202
  of thyroid, 233–237
  Paget's, 223, 225
  Parkinson's, 121
  Potts', 206
  prevention of infectious, 3
  renal, 169–170
  venereal, 173
Disinfection of excreta, 90
Dominance, principle of, 19; incomplete, 20
Dominants, "extracted," 20
Draughts, 64
Dropsy, 99, 118
Drosophila, duration of life in, 27
Dublin, Louis I., 156
Dullness, mental, 38
Duodenum, 179, 194, 195
Dura mater, 198
Dust, 66
Dysentery, 34, 90

E

Ears, running, 85
Eclampsia, 187
Eczema, 35
Edema, 99
Education, compulsory, 58
Egg cell (*see* Ovum)
Elastic tissue, atrophy of, 14, 15
Electric lighting, 66
Embolism, 151, 211
Emphysema, 15
Encephalitis lethargica, 206, 212, 217.—*See also* Sleeping sickness
Endarteritis, syphilitic, 207
Endocarditis, 142, 143
Endocrine glands, diseases of, 232–242
Endocrinology, 100, 101, 102
Engineering, sanitary, 53
Entomology, medical, 53
Environment:
  factors of, 10
  "good," 41
  importance of, 7
  influence of, 10, 45, 46, 57.—*See also* Euthenics
  knowledge of, 13
  relation to health and disease, 28–41
Enzymes, pancreatic, 194.—*See also* Amylase, Lipase, Trypsin
Epidemics, 56
Epilepsy, 48, 49, 205
Epileptics:
  marriage of, 48
  segregation of, 49
Epinephrin, 129
Errors, dietary, 72
Ether, 31

Eugenics, 42–52.—*See also* Heredity
Eunuchoidism, 99
Euthenics, 45
  air in, 53–67
  food as a factor in, 68–98
Evolution:
  doctrine of, 9 (*see* Species, origin of)
  progress of human, 45
Excreta, disinfection of, 90
Excretory channels, 78–84
Exercise, 31, 37, 41, 71, 73, 91, 134
Expectation of life, 54–55
Experiments in Plants Hybridization, 19
Exposure, 32
Extract, thyroid, 73
Extrasystole, 148

F

Failure, circulatory, 153–156
Fainting, 115
Fallopian tubes, 34
Fats, 33, 68, 69, 70, 73
Feeble-minded, marriage of, 48
Fertilizing cell (*see* Spermatozoön)
Fever:
  cerebrospinal, 216–217
  rheumatic, 126, 143–145, 157, 159, 160, 226
  scarlet, 128, 142, 144, 159
  typhoid, 157, 159, 169, 184, 185, 186, 191, 208, 226
Fibrillation, auricular, 150, 151
Fibroblasts, 15
Filtration, water, 87
Fluid, cerebrospinal, 198
Food, 33, 57.—*See also* Diet
Foot, club, 225; flat, 225
"Foxhall man," 45
Fumigation, 90

G

Gall bladder, 34, 40, 85, 89, 126, 179, 181–185, 195, 197, 229
Gallstones, 183–185, 193.—*See also* Cholelithiasis
Galton, Francis, 19, 46, 50
Gangrene, 122, 128
Gardening, 106–107, 162
Garments, thick, 57
Gaslight, 66
Gastritis, chronic, 94, 96
Gastro-intestinal tract, 180, 182, 186, 194, 213
"Genes," 28
Genito-urinary tract, 91
Genotype, 11, 12
Germ-carriers, 90, 184
Germ cells, 5–6, 10, 17, 94
Germicides, 66
Germ plasm, 10, 58
Glands:
  endocrine, 232–242
  "islands of Langerhans," 194, 196, 197, 232, 238, 239
  paratyphoid, 232
  pituitary, 130, 232
  prostate, 83, 166, 171, 173
  salivary, 78
  sex, 130, 232.—*See also* Gonads
  thyroid, 129, 130, 232–234
Glomerulus, 166
Gluttony, 41
Glycogen, 180
Glycosuria, 37, 238
Goiter:
  cause of, 37, 75, 234
  endemic, 234, 236
  exophthalmic, 99, 129
  "heart," 38
  prevention of, 235–237
  toxic, 38
Golfing, 162
Gonads, 100, 130.—*See also* Glands, sex
Gonorrhœa, 142, 173, 226
Gout, 36, 98, 99, 128, 132, 133, 227, 230
Grey, Viscount, 107
Guthrie, Dr. Clyde, 71

H

Habits, unhygienic, 105
Habitus,
apoplecticus, 12
asthenicus, 11, 12
determined by hereditary portion of constitution, 71
Hallucinosis:
alcoholic, 209
auditory, 26
visual, 26
Hands, cleansing of, 97
Harrison, 6
Hay fever, 35
Health, department of, authority and capacity of, 57
Heart:
"block," 146, 151
contractile power of under nerve control, 104
diseases, 3, 31, 95, 136–164, 195
effect of arterial changes upon, 29
rate, 114
structure and functions of, 136–141
"Heartburn," 95
Heating, 57
Hebrews, ancient, and hygiene, 56
Hemiplegia, 120
Hemophilia, 23, 25
Hemorrhage, cerebral, 130
Hemorrhoids, 189
Hepatic duct, 178
Hepatitis, chronic, 196.—*See also* Liver, diseases of
Heredity:
and circulatory system, 123–124
and gout, 133
and nervous system, 203–205
effect of environmental stimuli upon, 33
factors of, 10
in animals, 9, 38
in plants, 9
Heredity *(continued)*:
knowledge of, 13
problems of, 22
relation of health and disease to, 17–27
studies of, 9
type of nervous system predetermined by, 104.—*See also* Eugenics
Heredity and Environment in the Development of Men, 21 n.
Heroin, 210
His, bundle of, 138, 146, 151
Hobbies, 106, 219
Home, respiratory infections in, 67
Horseback riding, 106, 162
Houses, overheated, 64
Human machine:
intricacies of, 3
wearing out of, 2
Hunger, 41
Hybridization, 19–24, 47
Hygiene:
community, 56–58
industrial, 53
of infancy and childhood, 59–61
personal, 54, 58, 90
school, 54
sexual, 215
Hyperacidity, gastric, 95
Hyperglycæmia, 37, 238
Hyperpiesis, 124
Hypersensitiveness, 35
Hypertension, arterial, 124, 170, 172.—*See also* Blood pressure
Hypertrophy, prostatic, 173
Hypophysis, cerebri, 129, 232
Hypopituitarism, 99
Hypothyroidism, 38, 99, 234, 237.—*See also* Adenomata, toxic

I

Idiocy, amaurotic, 13
Idiokinetic changes, 18
Idiotype, 11

"Ids," 28
Imbecility, 51
Immigration as a factor in amalgamation, 49
Immunization, 91
Inmunology, 8
Individuals, origin of, 9, 17
Indol, 79, 181
Infancy and childhood, hygiene of, 59–61
Infection:
  amœbic, 34
  bacterial, 4, 85, 168, 240
  malarial, 34
  protection from, 41
  trypanosomal, 34
  venereal, 215
Infectious diseases, prevention of, 90–92
Infestation:
  fluke, 34
  hook worm, 34
  tapeworm, 34
Influenza, 56, 146, 206
Inheritance:
  phenomena of (*see* Individuals, origin of)
  sex-linked, 23
  study of, 24
Injuries, physical, 13
Inmatings, 51
Insane, hopelessly, marriage of, 48
Insomnia, 121
Insufficiency, aortic, 127
Insulin, 37, 100, 238, 239
Intermarriage. — *See* Consanguinity
Intestinal area, 121, 177
Intoxication, alcoholic, 31; protein, 31
Iodid:
  potassium, 133
  sodium, 133
Iodin, 69, 75, 95, 235, 236
Iron, 69
"Islands of Langerhans," 194, 196, 197, 232, 238, 239

J

Jaundice, 182, 196
Joints:
  diseases of, 225–229
  effects of infection upon, 25
  prevention of chronic degeneration of, 229
Joslin, E. P., 239
Journal of the American Medical Association, 239 n.

K

Kidneys:
  arteriosclerosis and, 119
  diseases of, 3, 16, 168–176
  effect of alcohol on, 94
  effect of arterial changes upon, 29
  from a hygienic standpoint, 81–84
  structure and functions of, 165, 168
Korsakoff psychosis, 210

L

Laennec's cirrhosis (*see* Cirrhosis, atrophic)
Lamarck, 17
Lamps, oil, 66
"Langerhans, islands of," 194, 196, 197, 232, 238, 239
Larynx, 95
Laxatives, use of, 176
Lead, 31, 35, 84, 97, 125, 130, 208.—*See also* Poisons
"Leg, limping," 96
Lesions:
  bacterial, 34
  vascular, 119
Leucin, 99
Life:
  a continuum, 4
  degenerative diseases of in later, 12
  duration of, 7
  expectation of, 54–56
  origin of, 4
Life Extension Institute, 91

Lipase, 194
Liver:
cirrhosis of, 9, 26, 35, 89, 93, 94, 239
diseases of, 185–190
structure and functions of, 177–184
Living matter, physico-chemical changes of, 3
Locomotor apparatus, 222, 226, 229
Locomotor ataxia, 16, 206
Loeb, 6
Longevity, 26–27, 53, 97, 174
Lugol's solution, 133
Lungs, emphysema of, 15
Luxury, 31

M

Magnesium, 69
Malaria, 87, 90, 191
Malnutrition, 12, 18
Marine, 75, 235, 236
Marriages:
consanguineous, 51, 204
of congenitally blind, 48
of deaf mutes, 51
of epileptics, 48
Mastication, 76, 78
Mating, selective, 45
McCarrison, 234, 235, 236
McLaughlin, Dr. Allan J., vii
McLeod, 100
Measles, 25, 60, 85, 87, 169
Medicine, preventive, 16, 53
Medulla oblongata, 36, 201
Membrane, mucous, 64, 182, 217
Mendel, Gregor, 19, 20
Mendelian characters, 204; experiments, 23; factors, 47; laws, 27; ratios, 21, 22
Meninges, 198
Meningitis, 85, 87, 206, 209, 216. —*See also* Fever, cerebro-spinal
Meningococcus, 216
Menopause, 124, 129, 204
Mercury, 31, 35, 84, 95–97, 169. —*See also* Poisons
Mess-room accommodation, 97
Metabolism:
disease of, 74
normal and abnormal, 98
of carbohydrates, 99, 180
of fats, 69, 99, 180
of proteins, 99, 180
products of, 36
what constitutes, 35
Metchnikoff, 80
Middle Ages, comparative immunity from diseases, 56
Migraine, 203
Milk supply, regulations regarding, 87
Monstrosities, 30
Morgan, 27
Morphin, 210
Mortality statistics in the United States, 3
Mosquitoes, 87, 90
Motoring, 162
Mucous membrane, 64, 182, 217
Mumps, 60
Muscles:
diseases of, 229
prevention of degenerative conditions, 229
sluggish, 38
"Mutations," 47
Myocarditis, 142, 196
Myocardium, 38
Myositis, 229.—*See also* Muscles, diseases of
Myotonia congenita, 51, 204
Myxœdema, 38, 101, 234, 237

N

Naunyn, 238
Nausea, 40
"Neanderthal man," 45
Nephritis, 89, 168, 169, 196, 197, 203
Nerves:
peripheral, 198, 200, 201, 209–210
sensory, 200, 201
vasomotor, 103

Nervousness, 134
Nervous system:
and uremia, 172
alcohol and, 94
autonomic, 103, 104
degeneration, 37
different parts of, 39
diseases of, 198–221
inherited characteristics of, 13
insular sclerosis of, 16
lesion of, 216
structure and functions of, 198–203
Neuritis, 26, 210, 213
Neuroglia, 198
Neurones, sensory, 199, 201; motor, 202
New York Medical Journal, 174
Nitrate, uranium, 89
Nitrogen in atmosphere, 62, 63

O

Obesity, 38, 72, 73, 101, 125, 130, 131, 132, 134, 147, 239, 241–242
Offices, overheated, 64
Oliguria, 168
"On the Advantages of a Trace of Albumin and a Few Tube Casts in the Urine of Men Over Fifty Years of Age," 174
Optic nerves:
atrophy of, 207
swelling of, 212
Osler, Sir William, 93, 174, 175
Osteitis deformans, 225.—*See also* Paget's disease
Osteomalacia, 223, 224, 231.—*See also* Bones, diseases of
Osteoporosis, 223.—*See also* Bones, diseases of
Outmatings, 51
Ovaries, 101, 102
Overeating, 37
Over-nutrition, 98, 132
Overwork, 13, 41, 105
Ovum, 5, 10, 23, 28, 30
Oxybutyric acid, 37
Oxygen in atmosphere, 62, 63

P

Paget's disease, 223, 225
Panama Canal Zone, 34
Pancreas, 100, 101, 179, 193–197, 237–242
Pandemics, 56
Paralysis:
agitans, 121
flaccid, 202
infantile, 207.—*See also* Poliomyelitis
of bladder, 207
partial, 26
spastic, 51, 202, 204, 211
Parasites, animal, 31, 34
Parasitology, 8
Paratype, 11, 12
Paratyphoid fever, 87
Paresis, 207
Parkinson's disease, 121; syndrome, 212
Parthenogenesis, 5
Paton, Stewart, 134
Pearl, Raymond, 7 n., 15, 26, 27, 30, 93
Pearson, 27
Pectoris, angina, 118, 119, 122
Pellagra, 74, 99, 213, 220
Pericarditis, 142
Pericardium, 136, 141
Pharynx, 95, 160
Phenotype, 10
Phosphorus, 69, 89, 180, 187
Phosphorus necrosis, 223.—*See also* Bones, diseases of
Physical factors, 31, 32
Pia mater, 198
Piles—*See* Hemorrhoids
"Piltdown man," 45
Pituitrin, 129
Plague, bubonic, losses from, 56
Plants, heredity and development in, 9
Plate, 25
Play, 31

Ploetz, 27
Pneumococcus, 62
Pneumonia, 85, 99, 125, 142, 157, 186
Poisoning, uremic, 16
Poisons:
  bacterial, 34, 85–92, 95–97
  chemical, 13, 18
  endogenous, 98–102
  exogenous, 130
  extraneous, 93–97
  from goiter, 147, 148
  from infection, 157
  inorganic, 31
  metabolic, 127, 131
  mineral, 58, 97, 169, 180
  organic, 58
Poliomyelitis, 206, 216, 217.—*See also* Paralysis, infantile
Polyarthritis, 226
Polypeptids, 79
Polyuria, 168, 238
Potassium, 69
Potts' disease, 206
Poverty, 31
Pratt, 154
Prenatal care, 58–59
"Pressure, systolic," 112; diastolic, 113; pulse, 113
"Prevention of Diabetes Mellitus," 239 n.
Prophylaxis, knowledge of, 60
Prostate gland, 34, 83, 166, 171, 173
Prostatectomy, 174
Prostitution, repression of, 215
Proteins, 33, 68, 69, 70, 82, 83
Proteoses, 79
Protozoölogy, 53
Pseudo-angina, 153
Pseudo-reminiscences, 26
Pseudo-rickets, senile, 225.—*See also* Paget's disease
Psychic-contagion, 104, 105
Psychic factors, 31, 38, 103–108
Ptyalin, 78
Puberty, premature, 99
Public Health Series, vii
Pulse deficit, 150
Purgatives, use of, 176
Purins, 11, 37, 74, 84, 128, 133, 165, 226, 227
Pylorus, 78
Pyorrhœa, 176

Q

Quarantine, 53, 60, 90

R

Race Hygiene and Heredity, 50
Radiators, hot-water, 66
Rag-pickers of Paris, riot of, 56
Ratios, Mendelian, 21, 22
Recessives, "extracted," 20
"Recreation," address on, 107
Recreation, out-of-door, 106
Regeneration, power of, 7
Regimens, dietetic and hygienic, 160, 219
Regurgitation:
  aortic, 127, 143
  mitral, 143
"Rejuvenation," 102
Relaxation, 105, 219
Renal disease, 169–170
Reproduction, 5
Rest, 31, 41, 219
Retinitis pigmentosa, 51, 204
Rheumatism, 128,—*See also* Fever, rheumatic
Rickets, 223, 224.—*See also* Bones, diseases of
Rosenau, 95
Rowntree, 33

S

Salts, mineral, 33, 63, 73
Sanitation, 53, 85
Scarlet fever, 84, 85, 128, 142, 146, 208
Schick test, 60, 86
Sciences, biological, 3
Sclerosis:
  insular, 16
  multiple, 25
Scurvy, 34, 74, 94
Secretions, perverted, 31

Segregation, of degenerates, 49; of defectives, 49; of epileptics, 49; principle of, 19
Selection, natural, 47; artificial, 47
Senility, 14
Sepsis, 8, 84
Septicemia, 142, 146, 226
Serum:
Flexner's antimeningococcus, 207
"senescent," 15
"young," 15
Sewage disposal, 53, 57, 87, 90
Sex glands, 101, 102
Sexual characteristics and instincts, secondary, 36
Sheath, myelin, 198, 202
Sick rooms, fumigation of, 90
Siemens, 50
Sinus arrhythmia, 148
Sinuses, paranasal, 34, 72, 88, 89, 126, 229
Skatol, 18, 79
Skin, dryness and swelling of, 38
Sleep, insufficient, 105
Sleeping sickness, 212
Smallpox, 9, 60, 86, 91, 169
Smoke, 66
Sneezing, 63, 67
Snow, 27
Social factors, 31, 38, 103–108
Sodium, 69, 99, 165, 175
Species, origin of, 9, 17
Spermatazoa, 5, 10, 23, 30, 102
Sphygmomanometers, 132
Spinal cord, 39, 171, 198, 201, 206, 207, 208, 212, 213
Spine, tuberculosis of, 206.—*See also* Potts' disease
Splanchnic area, 121, 122
Spleen, 177, 186, 190
Sprue, tropical, 213
Starch, animal, 180.—*See also* Glycogen
Stasis, colonic, 80
Statistics, vital, 53; mortality, in city of Breslau, 54; compilation of, 58; Joslin's, 72
Steinach, 101
Stenosis, aortic, 143, 145
Sterilization of unfit, 49
Stockard, 30
Stomach, catarrh of, 93
Streptococcus, 184
St. Vitus' dance, 25, 159
Succus entericus, 79
Sulphid, hydrogen, 79
Sulphur, 69
Sunlight, direct, 66
Sunstroke, 206
Supplies, food and water, purification of, 90
Suprarenal glands, 101
Swimming, 162
Symptoms, psycho-neurotic, 60
Syndrome, Parkinsonian, 212; Stokes–Adams, 152
Syphilis, 85, 89, 126, 142, 144, 145, 146, 157, 159, 160, 186, 207, 214–216, 226

T

Tabes dorsalis.—*See* Locomotor ataxia
Tachycardia, paroxysmal, 149
Teeth, 85, 89, 146, 159, 160, 163, 173, 184, 229
Tenements, overcrowded, 41
Tennis, 162
Testes, 101, 102
Tetany, 99
Theaters, respiratory infections in, 67
Throat, 85
Thrombosis, cerebral, 211
Thyroid gland, 37, 73, 75, 99, 100, 129, 130, 232–237
Tobacco, 13, 31, 39, 93–94, 95–97, 125, 130, 134, 145, 148, 163, 210, 220
Tonsillitis, 84, 85, 144, 157, 159, 160, 184
Tonsils, 34, 88, 89, 126, 163, 173
Toxin-antitoxin mixture, 87
Toxins, bacterial, 89
Tract, gastro-intestinal, 180, 182, 186, 194, 213, 219

Transportation, new methods of, 57
Trauma, 32, 205–206
Traumatic injury, 4
Tree, arterial, 103
"Trinil man," 45
Trypsin, 194
Tuberculosis:
  and measles, 9
  campaign against, 65, 89
  deaths from, 3, 157
  degenerative through, 85, 186
  morbidity from, 3
  pulmonary, 12
  traits which dispose to, 25
Tubes, Fallopian, 34
Tumor, brain, 212, 220
Tunica media, 114; intima, 114; adventitia, 114
Typhoid fever:
  acute nephritis from, 169
  causes of, 34
  decrease of, 87
  defense against, 91
  degeneration through, 85, 125, 146
  knowledge how to combat, 90
  morbidity from, 3
  mortality from, 3
Typhus fever, losses from, 56
Tyrosin, 99

U

Under-nutrition, 98.—*See also* Malnutrition
Unemployment, 41
Unfit, sterilization of, 49
Unit characters, principle of, 19
United States,
  death rate in, 4
  mortality statistics in, 3
United States Army, Navy and Public Health Service, 215
Urea, 82, 83, 119, 165
Uremia, 82, 99, 119, 171, 172
Ureters, 83, 166, 169, 170, 171, 174
Urethra, 83, 166, 169, 170, 171, 173
Uric acid, 11, 31, 36, 69, 74, 99, 128, 165, 227, 230
Urine, 165–171, 205
Urogenital tract, 229

V

Vacations, 105, 134, 164, 219
Vaccination, 60, 86, 87, 91
Vas deferens, 102
Vasectomy, 49
"Vater, ampulla of," 195; "papilla of," 195
Veins, 111
Vena cava, 178
Venereal infection, 215
Ventilation, 12, 41, 64–67, 97
Vision, dimness of.—*See* Amblyopia toxic
Vitamins, 33, 34, 69, 73, 74, 220
Voronoff, 101

W

Walking, 106, 162
Wall, arterial, 16
Walworth, 26
War, 49
Washing, facilities for, 97
Water, 33
Water supplies, 53, 58
Weight, ideal, 71
Whooping cough, 60, 88, 159
Wilson, James, 363
Work, 31
Worker, sedentery, 106
Workrooms, cleanliness in, 97
World War, 91
Worry, 105
"Wrist drop," 210

Y

Yellow fever:
  conquest of, 9
  fight against, 90
  loss of life by, 56

Z

Zygote, 10, 22, 28

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